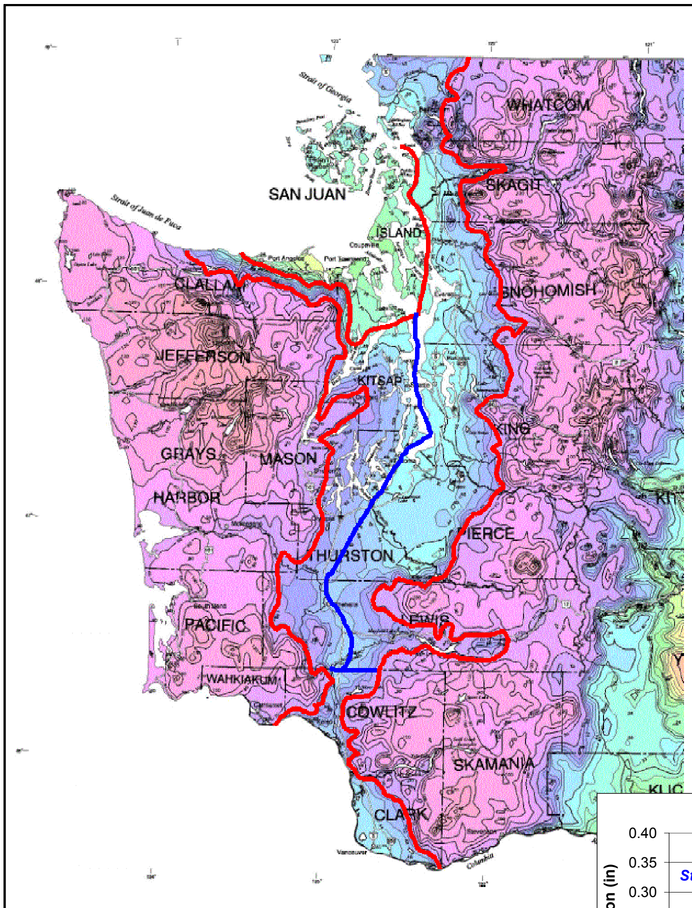
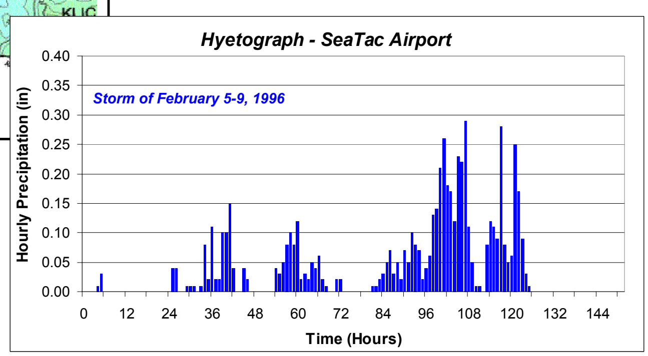
MGS Flood – Version 3 Training Workshop

A Continuous Hydrological Simulation Model for Stormwater Facility Analysis for Western Washington





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MGSFlood Version 3 Overview
Review Continuous Hydrologic Modeling
Stormwater Detention Standards

Bruce Barker, P.E.

MGS Flood
Training Workshop

MGSFlood
Continuous Flow Model for Stormwater Facility Analysis

Training Workshop

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MGSFlood New Features

Multiple Structures

- **Detention/Infiltration Ponds, Sand Filters**
- **Open Channel Flow, Complex Shapes**
- **Infiltration Trenches**
- **User Defined Rating Tables**
- **Flow Splitters**

MGSFlood New Features

- ❖ **Optimizer Works for Ponds and Trenches**
- ❖ **Structure Infiltration based on Massmann**
- ❖ **Pond Elevation-Frequency, Graphs & Tables**
- ❖ **Island County Timeseries; Puget E, 24” & 28” MAP**
- ❖ **Better Project Reporting**

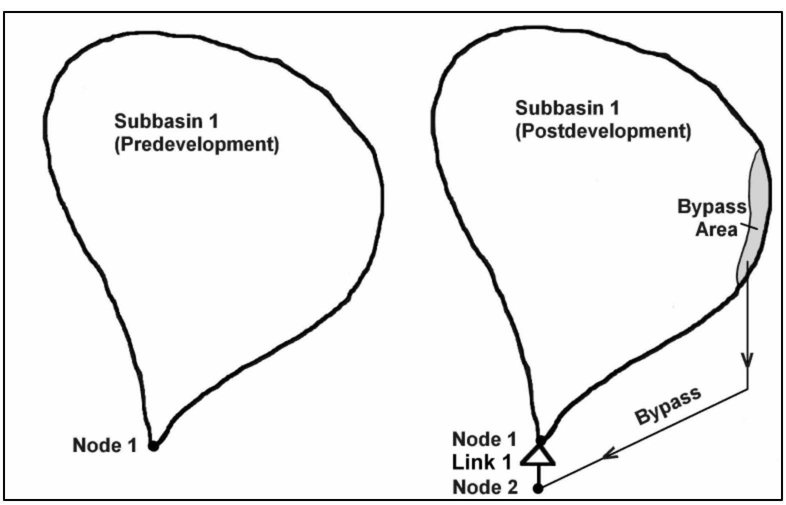
MGSFlood New Features

- ❖ **Ability to Include or Omit Surface, Interflow, or Groundwater for Any Land Segment**
- ❖ **Lateral Flow Connections Between Land Segments Allows for Simulation of Flow Dispersion**
- ❖ **HSPF V12, High Groundwater may be Defined for Any Land Segment in the Project**
- ❖ **Wetland Water Level Fluctuation Analysis According to Guide Sheet 2**

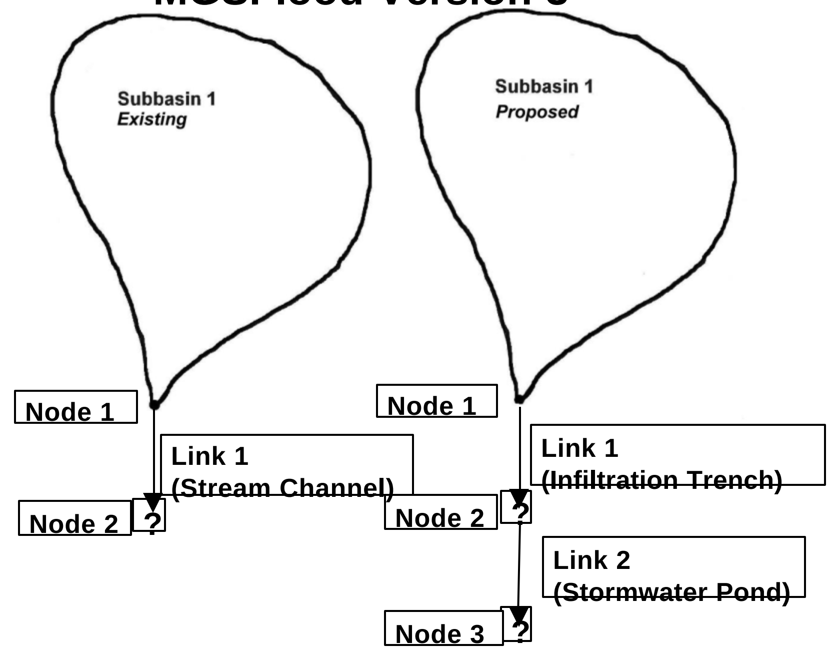
MGSFlood New Features

- ❖ Simulation is now Controlled by Single Button that Computes Runoff, Routing and Optimization
- ❖ Graphs have Been Improved to Allow better Customization
- ❖ The Default Project Directory Can be Saved (even on a Network)
- ❖ Project Report Uses Windows RTF Formatting
- ❖ Graphical Network Definitions Under Development
- ❖ GIS Interface Under Development

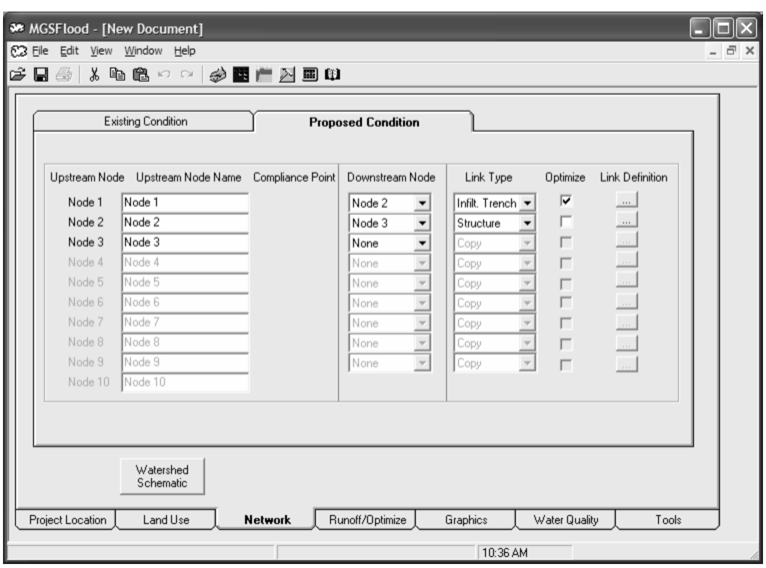
MGSFlood Version 2



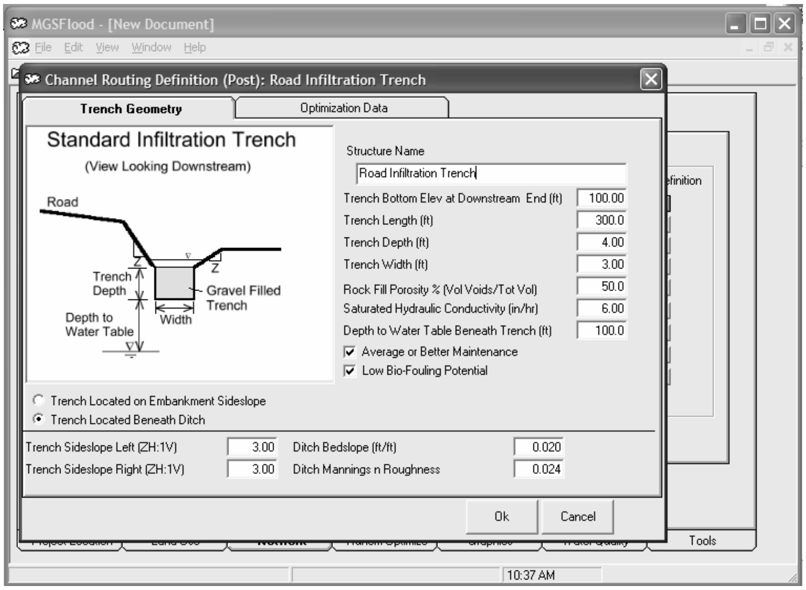
MGSFlood Version 3



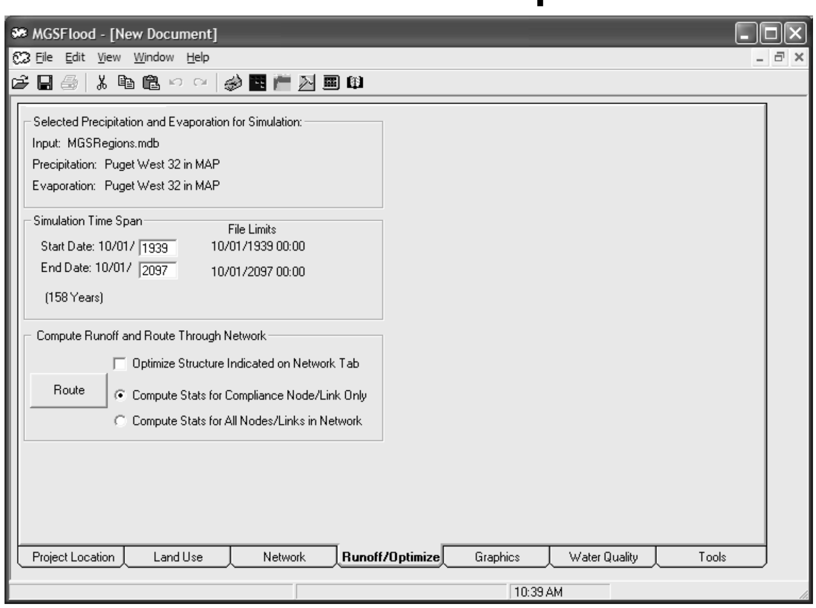
MGSFlood Network Input

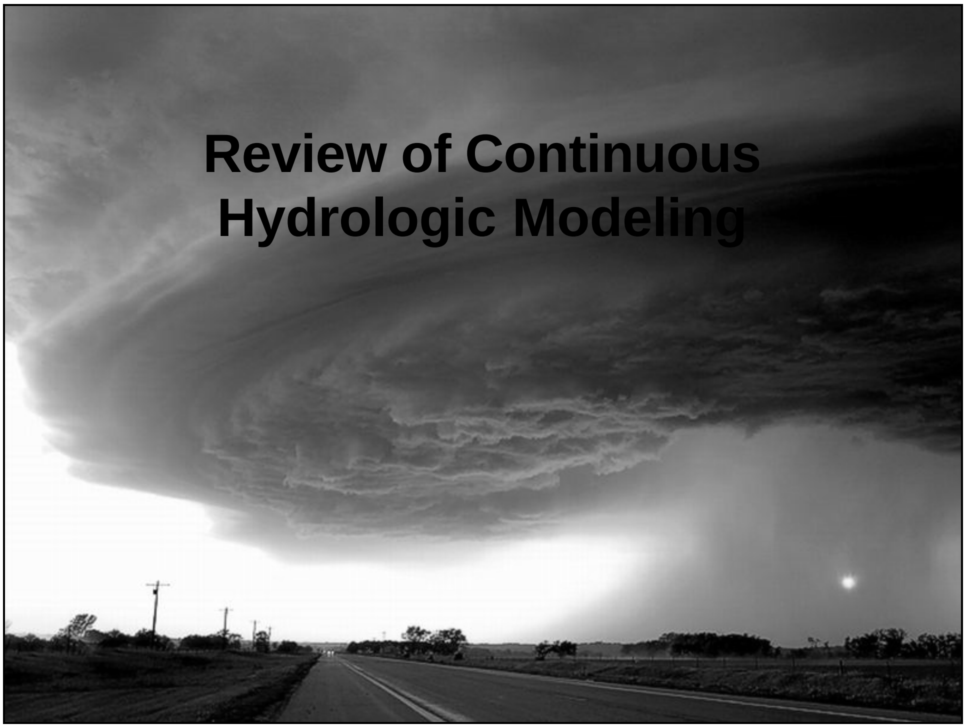


MGSFlood Infiltration Trench Input



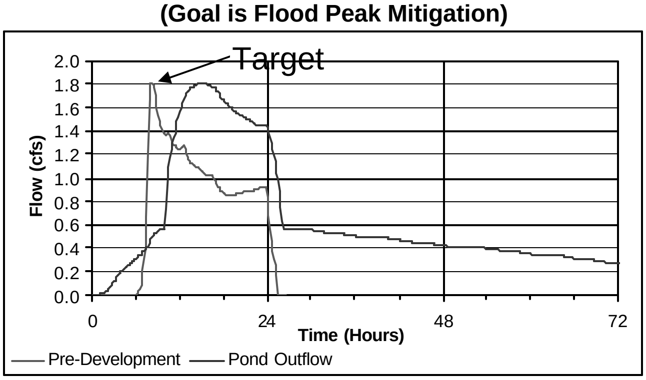
MGSFlood Runoff Optimize





Single Event Pond Design

(Goal is Flood Peak Mitigation)



(Hydrographs Computed Using SBUH)

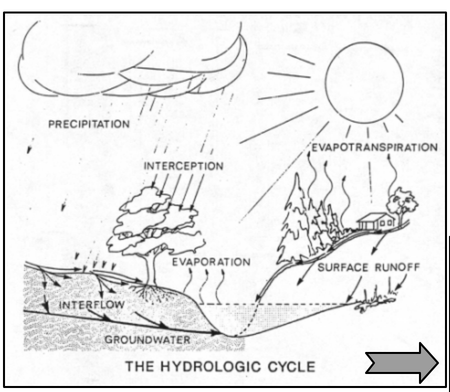
- **Flood Peak is Reduced to Predeveloped Level, but higher Runoff Volume Extends Length of Flood**
- **Results in More Erosive Work done on Stream Channel than in Predeveloped Condition**

Continuous Rainfall Runoff Analysis

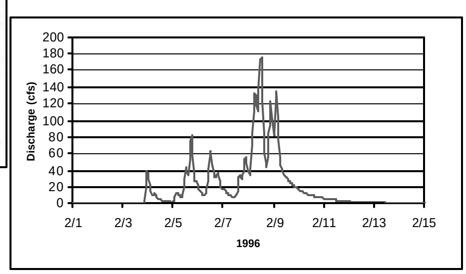
(HSPF, MGSFlood, KCRTS)

- **Uses Continuous Precipitation, Evaporation**
- **Keeps a Running Accounting of Moisture in Canopy, Ground Surface, Soil, and Groundwater**
- **Computes Decades-Long Runoff at Hourly Timesteps**
- **Computes Surface, Interflow and Groundwater**
- **USGS Developed Model Parameters for Common Soil types and Land Cover in Western Washington**

Hydrologic Processes Simulated by MGSFlood



Processes Simulated by MGS Flood (HSPF Runoff Algorithms)



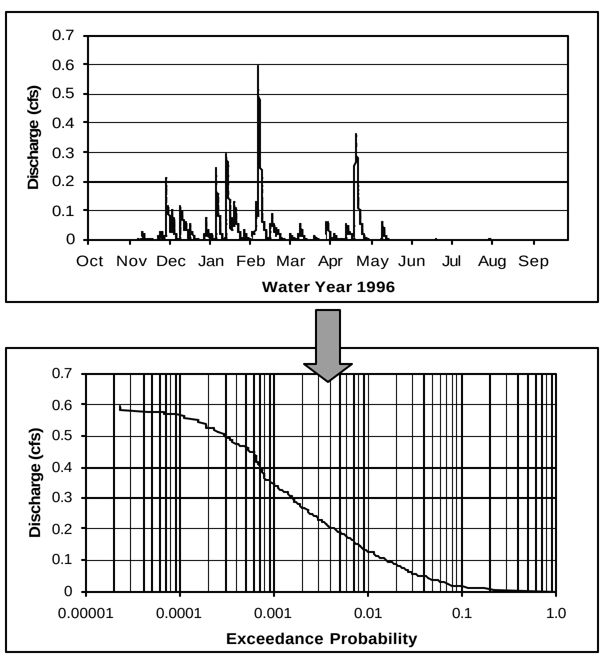
Example Model Output

Use of Continuous Flow Model for Pond Design

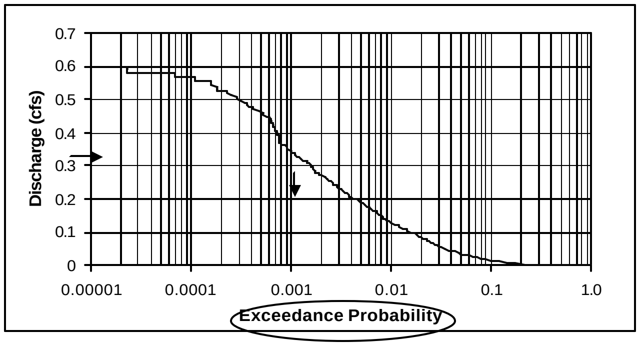
- **Hydrological Simulation Program FORTRAN (HSPF) is the basis for MGS Flood, KCRTS, and WWHM** (HSPF http://www.epa.gov/ceampubl/ceamhome.htm)
- **Simulates hourly runoff for 50 to 150 years (depending on precipitation/ evaporation input)**
- **Allows for pond performance to be evaluated using a wide range of storms and antecedent conditions,**
- **Allows for Calculation of *Flow Duration Statistics*, which are used to design ponds for Channel Stability,**
- **Rainfall-Runoff algorithms in HSPF are more detailed than SCS, produces much better estimates of runoff.**

Flow Duration Definition:

Track the Fraction of Time that a Given Flow is Equaled or Exceeded



Flow Duration Graph - What it Means



Exceedance Probability - is the Fraction of Time that the Discharge is Equaled or Exceeded During Simulation

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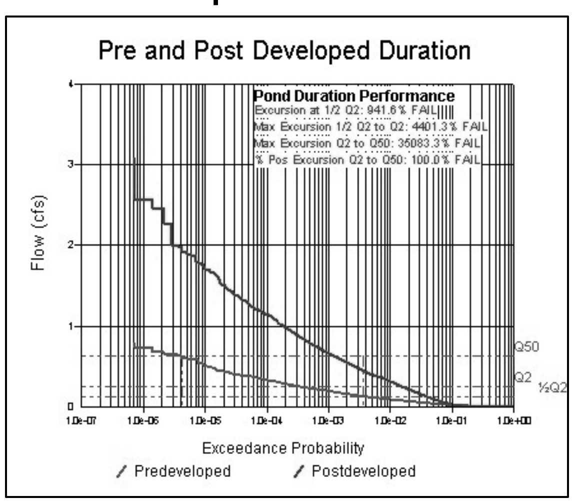
Example: Find Average Hours per Year 0.35 cfs is Exceeded

At Discharge=0.35 cfs, Exceedance Probability =0.001
0.001*(365.25 Days/Year)*(24 Hrs/Day)= 9 Hours/Year

Pre and Post Development Flow Duration Curves



Developed Condition:

- ❖ **Higher Flows Occurring for Longer Duration**
- ❖ **Results in More Erosive Work Performed on Channel**

Pond Design for Channel Stability

Minimize the Amount of Erosive Work Done to Stream Channel

Control the Duration of Flow to Predeveloped Levels Above the Bedload Movement Threshold

Bedload Movement Threshold:

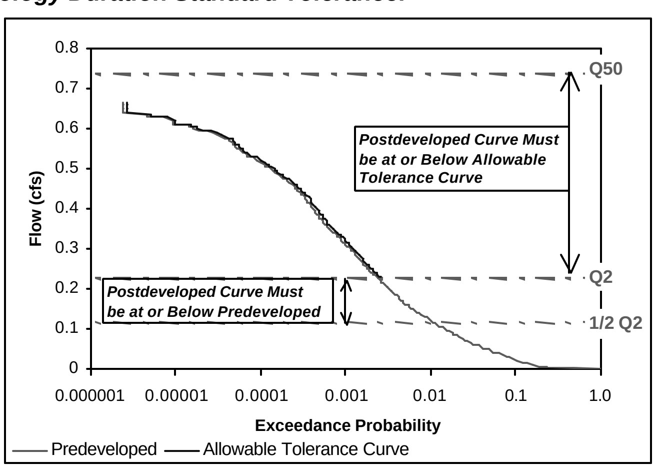
"A rate of about 50-percent of the predevelopment 2-year discharge is a credible generic value for the initiation of sediment transport in gravel-bedded streams …"

(Derek Booth, 2000)

Ecology Flow Duration Standard for Pond Design

Match developed flow Duration Curve to predeveloped Curve from 50-percent of the 2-year to the full 50-year peak flow.

Ecology Duration Standard Tolerance:



Flow Duration Standard Matching Criteria

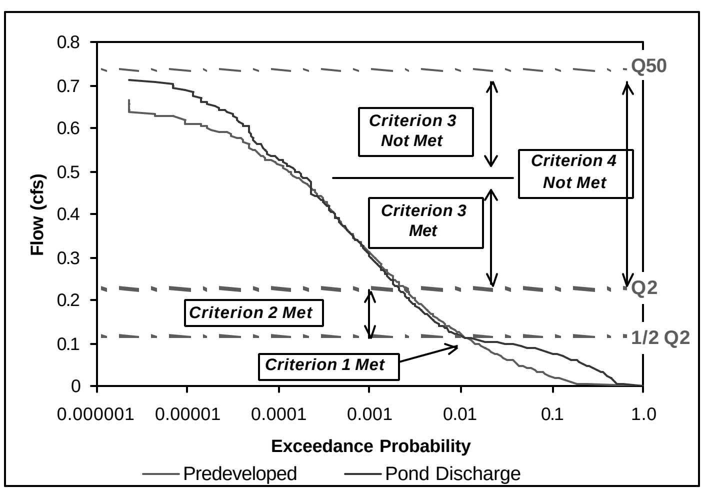
***<u>Excursion Definition:</u>* A Measure of the difference between an observed value and a target value**

In the Case of Flow Duration Curves:
<u>Observed Value</u> is the Pond Outflow
<u>Target Value</u> is the Predeveloped Discharge

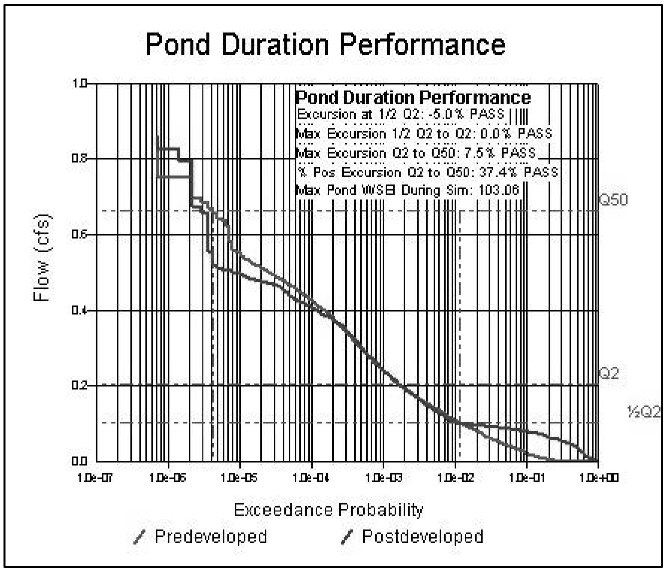
<u>Ecology's Matching Criteria</u>

1. **Excursion at ½ Q_2 <=0**
2. **Maximum Excursion from ½ Q_2 to Q_2 <=0**
3. **Maximum Excursion from Q_2 to Q_{50} must be within 10% of the Predeveloped Curve Duration (i.e., Measured Horizontally on Graph)**
4. **Percentage of Positive Excursions from Q_2 to Q_{50} <=50% (this criterion is usually met if 3 is met)**

Pond Performance Example

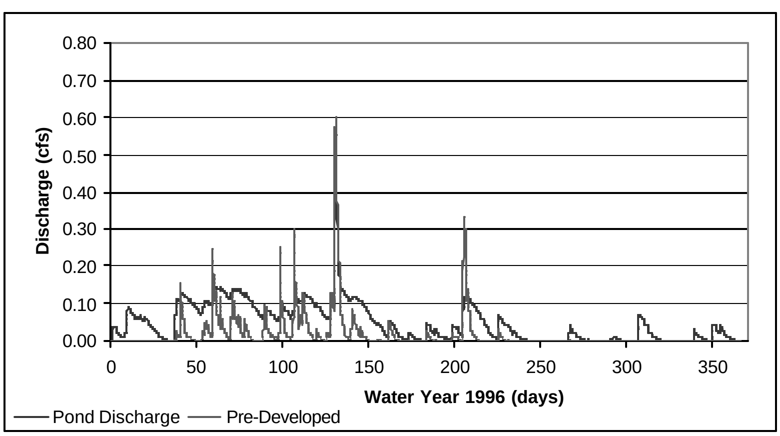


(Pond Fails Criterion 3 and 4 Does not Meet Flow Duration Standard)



MGSFlood Pond Duration Performance Plot for Pond that Meets Flow Duration Design Standard

Performance of Duration Standard Pond



What About Flood Control?

- **Control the Flood Peak Discharge at Some Defined Magnitude (Commonly the 25- or 100-year Recurrence Interval)**
- **If Flood Peaks are of Interest in Addition to Flow Durations, Perform <u>Flood-Frequency</u> Analysis to Check Flood-Peak Performance**
- **Flood-Frequency Analysis is Fundamentally Different From Flow Duration Analysis**
- **Good News is that Ponds Designed to the Flow Duration Standard do a Good Job at Reducing Flood Peaks**

Flood-Frequency Calculation

Single Event Model

Flood Recurrence Interval Equals Precipitation Recurrence Interval
(Unfortunately, this is rarely true!)

Continuous Model

1. Get Highest Flow Peak from Each Year of Simulation
2. Rank the Flows from Highest to Lowest
3. Assign Recurrence Interval (*Tr*) to Each Flow
   Using the ***Plotting Position*** Formula:

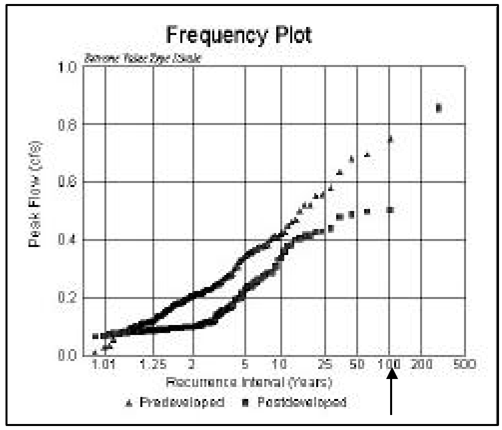
$$Tr = \frac{N + 0.12}{i - 0.44}$$

**Where: N is the total number of years simulated
i is the rank of the peak flow from
highest to lowest.**

(Performed Automatically by MGSFlood)

Flow Duration Pond, Peak Flow Performance

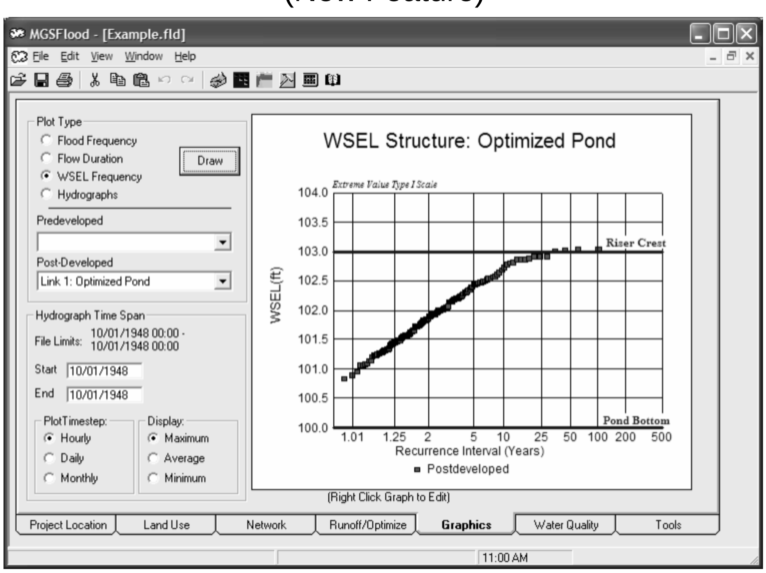
MGSFlood Flood Peak Performance Plot



Generally, Ponds Designed to the Ecology
Flow Duration Standard Control Flood Peaks to Predeveloped
Levels out to or beyond the 100-Year Recurrence Interval

Flow Duration Pond, Peak WSEL Performance

(New Feature)



WSDOT Highway Runoff Manual
Minimum Requirements

2000 sf of new and/or replaced Impervious Surface?

Yes

Apply Minimum Standards 1-4

1. **Stormwater Planning**
2. **Construction Stormwater Pollution Prevention**
3. **Source Control of Pollutants**
4. **Maintain the Natural Drainage System**

WSDOT Highway Runoff Manual
Minimum Requirements

5000 sf of new Impervious Surface or
¾ Ac Conversion of Native Vegetation to Lawn?

Yes

Minimum Standards 1-9 Apply to New Impervious and Converted Pervious Surfaces

1. **Stormwater Planning**
2. **Construction Stormwater Pollution Prevention**
3. **Source Control of Pollutants**
4. **Maintain the Natural Drainage System**
5. **Runoff Treatment**
6. **Flow Control**
7. **Wetlands Protection**
8. **Incorporate Watershed-Based/Basin Planning**
9. **Operation and Maintenance**

WSDOT Highway Runoff Manual
Minimum Requirements

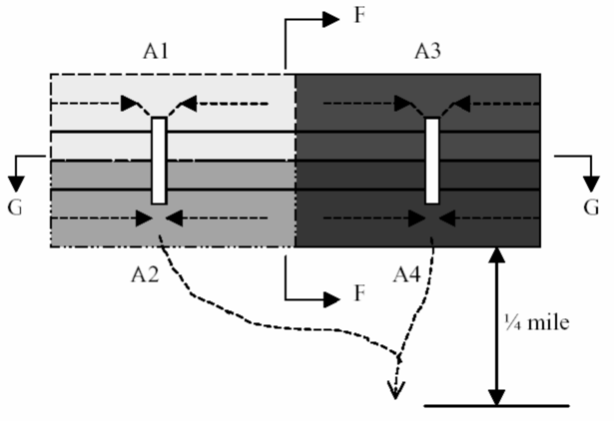
For Road Projects Adding 5000 sf of new Impervious Surface: Do new Impervious surfaces add 50% or more to existing impervious surfaces within the project limits?

Yes

Apply Minimum Standards 1-9 to Replaced Impervious Surfaces too

WSDOT Highway Runoff Manual
Threshold Drainage Areas

Threshold Drainage Area (TDA): ***An on-site area draining to a single natural discharge location or multiple natural discharge locations that combine within ¼ mile***



In this Case, A1, A2, A3, A4 Could be combined into a single TDA

WSDOT Highway Runoff Manual
Separation of Off-Site and On-Site Flow

Definitions:

- **On-site:** The area that includes the proposed development.
- **Off-Site:** Any area lying upstream of the project site that drains onto the site, and any area lying downstream of the site to which the site drains.

- **Mitigated Area:** New or replaced impervious surface that will receive flow control.

Non-Mitigated Area: Existing on-site Impervious or Pervious Surface.

WSDOT Highway Runoff Manual
Separation of Off-Site and On-Site Flow

- ❖ **Runoff from existing non-mitigated on-site impervious surface may NOT be routed to the stormwater pond if:**

  The ratio of the 100-year runoff rate from existing developed areas to the 100-year runoff rate from the new developed areas is greater than 50% (this ratio is computed on undetained flows).

- ❖ **Effectively, you can assume an amount of existing Impervious Surface Equal to ½ of the Area of the New Impervious Surface for the Predeveloped Condition. The remainder must be Pervious**

<u>Example:</u>

Existing Lane Area: 2 Acres Impervious
New Lane Area: 1 Acre Impervious (Existing Condition Pasture)

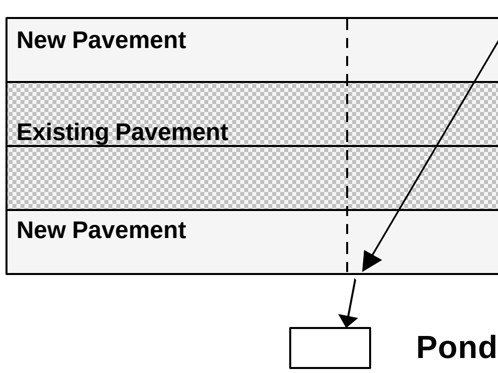
<u>Model Input</u>

Predeveloped: 0.5 Acres Impervious
2.5 Acres Pasture

Developed: 3.0 Acres Impervious

WSDOT Highway Runoff Manual
Separation of Off-Site and On-Site Flow

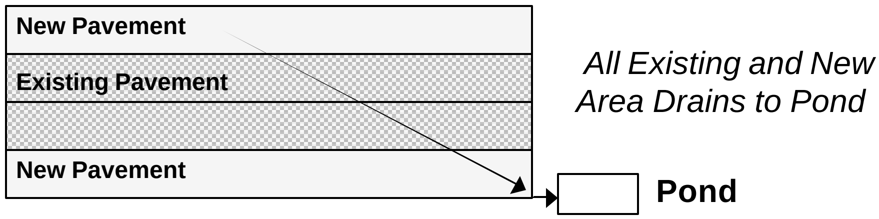
Option 1: "Equivalent Area" Concept



Area Draining to Pond is Equal to Area of New Pavement Added (Includes both new and Existing Pavement)

WSDOT Highway Runoff Manual
Existing Impervious Surface

Option 2: Use "Full Area Concept"

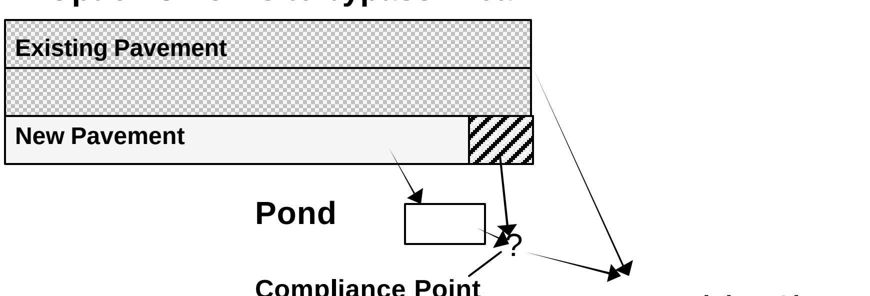


Design Procedure:

1. *Design Pond for New Area Only*
2. *Route Runoff from New and Existing Area to Pond, Ensure that the Overflow Riser has Sufficient Capacity to Pass the 100-year Flood*

WSDOT Highway Runoff Manual
Existing Impervious Surface

Option 3: On-site bypass Area



Design Procedure:

1. *Bypass Flows to Compliance Point Downstream of Pond*
2. *Oversize pond to compensate for bypassed flow*
3. *Existing Pavement is bypassed and not Included in Analysis*

Precipitation Time-Series

Mel Schaefer Ph.D. P.E.

MGS Flood
Training Workshop

MGSFlood Precipitation Input

Transposition and Scaling of Precipitation Time-Series

Ecology Simple Scaling Procedure

Extended Precipitation Time-Series

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Use of Precipitation Time-Series in Continuous Hydrological Modeling …

Quality of Rainfall-Runoff Modeling
only as good as the model inputs

Precipitation Time-Series
® one of the key inputs

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Use of Precipitation Time-Series in Continuous Hydrological Modeling …

Need a High Quality, Long-Term, Precipitation and Evaporation Timeseries

Typically, your project is not located near such a station

An hourly precipitation time-series must be <u>transposed</u> from “nearby” station and <u>scaled</u> to match expected precipitation characteristics at your project site

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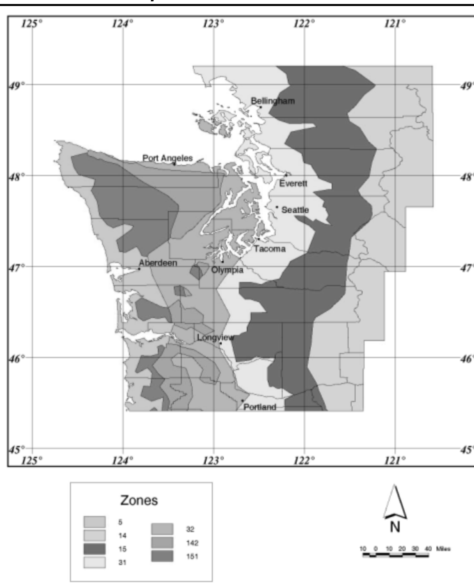
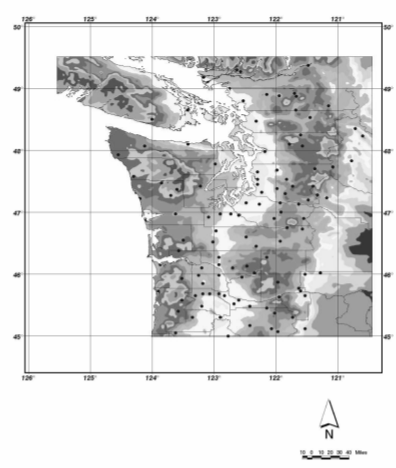
Climatic Zones for Precipitation Characteristics



Variability of Precipitation in Western Washington



Use of Precipitation Time-Series in Continuous Hydrological Modeling …

- *<u>Ecology Simple Scaling Procedure</u>*
  use nearest hourly precipitation gage and simple scaling procedure

- *<u>Extended Precipitation Time-Series</u>*
  created using regional statistics from numerous gages
  (Most Accurate/Reliable)

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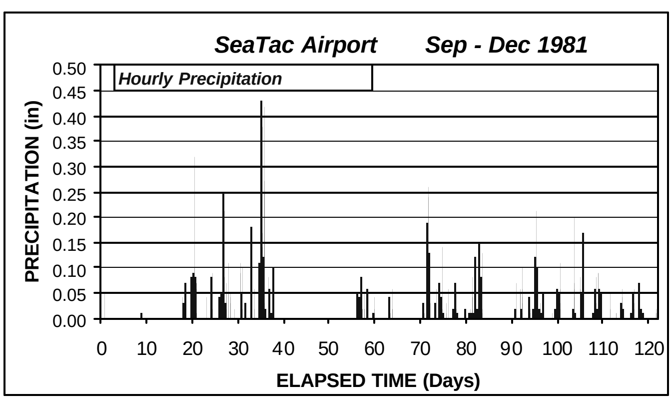
Hourly Precipitation Time-Series



Sequence of Hourly Precipitation

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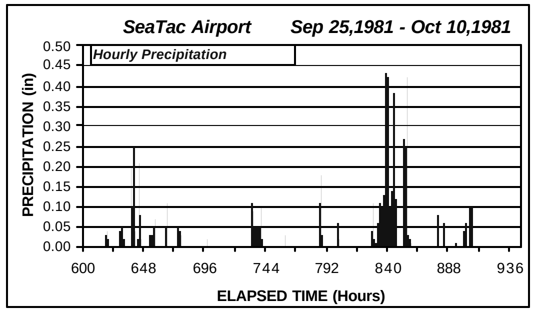
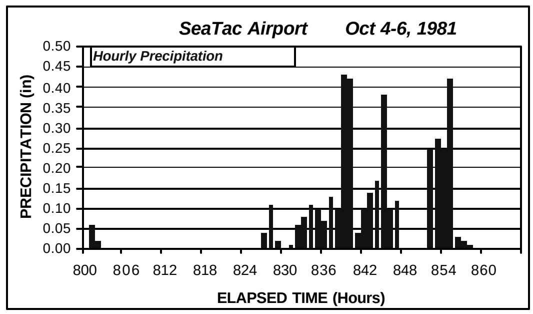
Hourly Precipitation Time-Series





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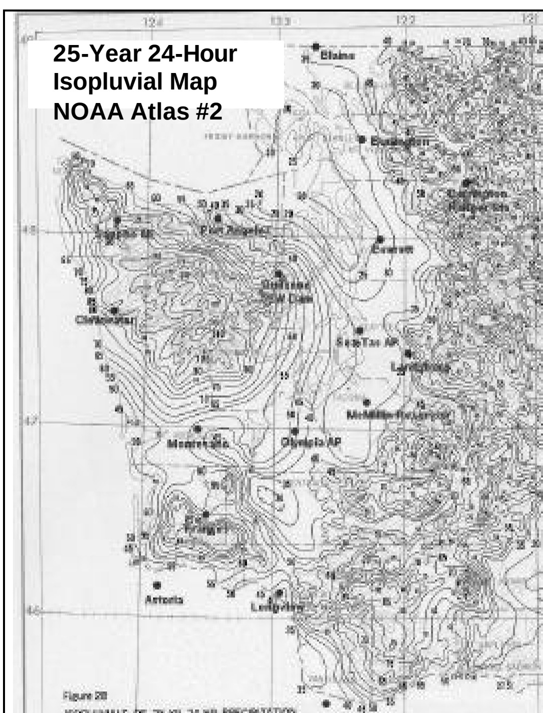


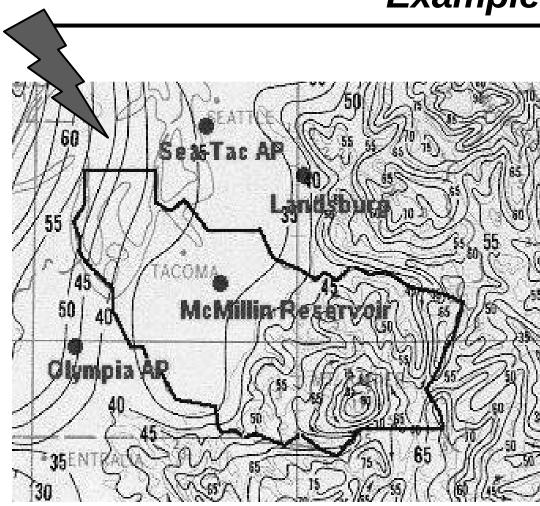
Simple Scaling

Use Nearest Hourly Gage

Multiply All Hourly Values by <u>Single</u> Scaling Factor

Scaling Factor is Ratio of 25-Year 24-Hour Precipitation at Site of Interest Relative to Gage

Ecology Simple Scaling Procedure … Example



Site of Interest in Kitsap County

5.1-inches 25-Year 24-Hour

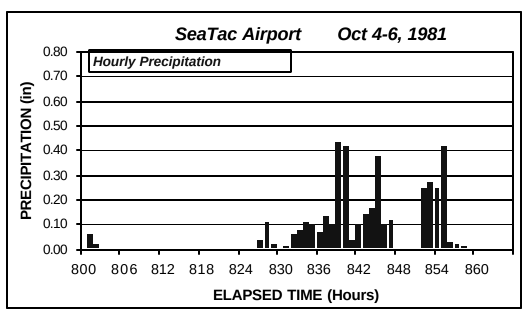
Use Sea-Tac Gage 3.1-inches 25-Year 24-Hour

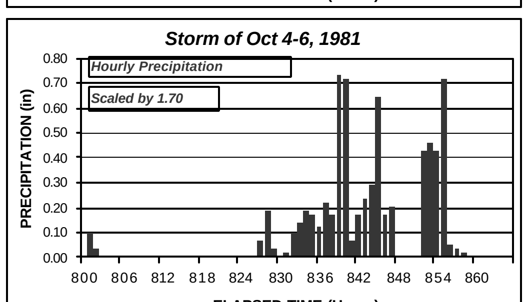
Scaling Factor = 1.70 (5.1/3.1)

25-Year 24-Hour Isopluvial Map - NOAA Atlas #2

<u>Simple</u> Scaling of Hourly Precipitation Time-Series

Every hourly amount scaled by 1.7 for Kitsap County Site





Simple Scaling Shortcomings

1. Nearest Gage <u>May Not</u> have "Representative" Record

By chance - via Mother Nature
Record may be an "active record"
with one or more extreme storm events (outliers)
Or
Record may be a "benign record"
with the absence of many noteworthy storms

And/Or
Record may be of poor quality
- missing data and machine malfunctions

Simple Scaling Shortcomings

2. Storm Characteristics Vary by Duration and Season

<u>Not Possible</u> to Rescale Time-Series
with <u>Single Scaling Factor</u>
and Obtain Correct Storm Characteristics
at all Durations at the Site of Interest:

Different Scaling Functions needed for range of durations:
2-hr, 6-hr, 24-hr, 3-day, 10-day, 30-day, 90-day, Annual

Simple Scaling Shortcomings

3. Many gages have short record lengths (< 40-years)

Record Length Usually Too Short
for Intended Design Purposes

® *Computation of Flow-Duration Curves at 50-Year Level*

® *Estimation of 100-Year Flood*

Solution to Shortcomings of Simple Scaling …

Extended Precipitation Time-Series

grew out of basic need for:

- *robust statistical method*

for transposing time-series from one site to another

Utilizes Statistical Scaling Functions
Applied at Multiple Durations

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Extended Precipitation Time-Series

- ***WHAT** is extended time-series record*
- ***WHY** use extended time-series record*
- ***HOW** were extended time-series developed*

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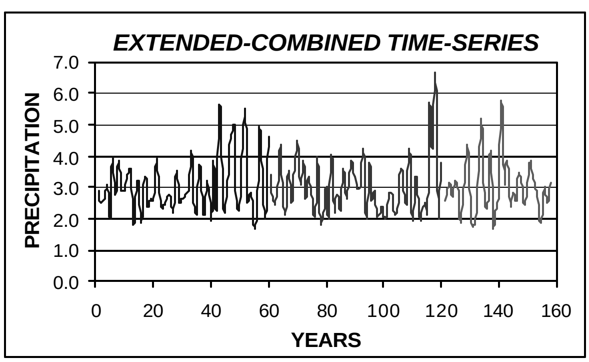
What is an Extended Precipitation Time-Series …

Long Precipitation Record

Obtaining by Combining Records from Distant Stations



Record from Each Station Rescaled
to have Storm Statistics Representative of Site of Interest

What is an Extended Precipitation Time-Series

Long Time-Series Created by Combining Precipitation Records

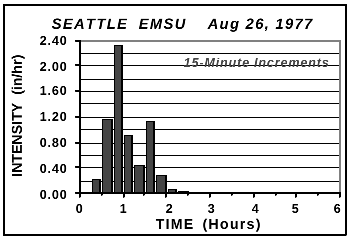
Vancouver, BC	*38-years*
Seattle, WA	*60-years*
Salem, OR	*60-years*

Why use Extended Precipitation Time-Series …

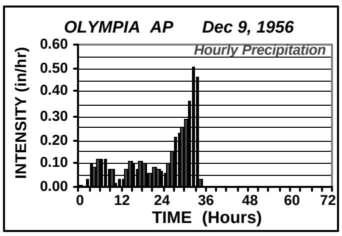
- *Allows use of high-quality stations with long records*
  - *Avoids pot-luck of using nearby stations*

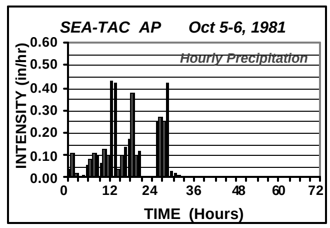
    Many hourly stations have short records of poor-quality
- *Provides greater diversity and variability of storm temporal patterns*
- *Provides for increased number of extreme events*
- *Allows <u>interpolation</u> of 50-year and 100-year floods rather than extrapolation*

Greater Sampling of Storm Magnitudes and Temporal Patterns

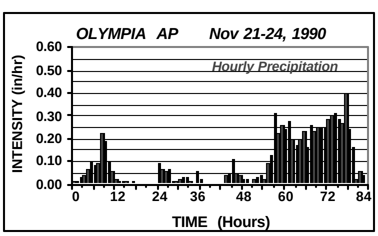


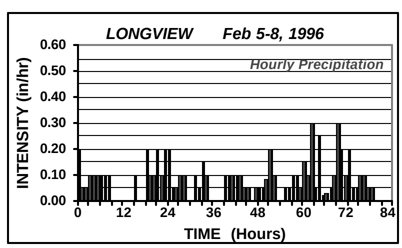
Larger Sample of Storm Temporal Patterns allows more rigorous testing of detention pond performance

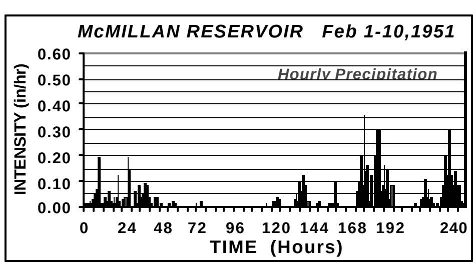




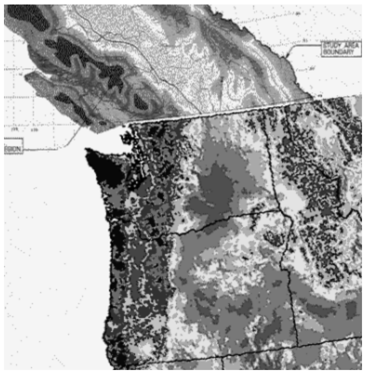
Greater Sampling of Storm Magnitudes and Temporal Patterns







HOW - Create Long Time-Series by Pooling Data from Climatologically Similar Areas



Non-Orographic Lowlands East of Coastal Mountains

- *Lowlands British Columbia*
- *Puget Sound Lowlands*
- *Willamette Valley*

Similarity

- *Seasonality of storms*
- *Storm temporal patterns*
- *Magnitude-frequency curves*

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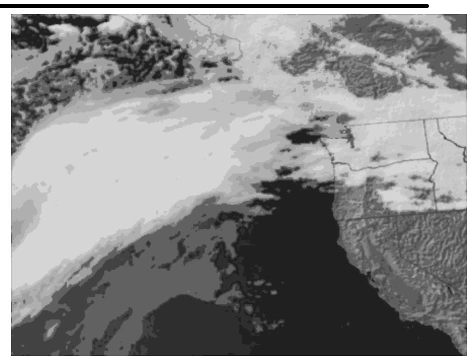
HOW - Create Long Time-Series by Pooling Data from Climatologically Similar Areas …

Independence of Data Allows Combining of Precipitation Records

Widely Separated Stations have Independent Records at Durations of Interest (affected by different storms)



Heaviest Precipitation Storm Tracks / Storm Centers Typically Cover Only Portion of Climatological Region

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Independence of Storms at Widely Separated Stations 24-Hour Precipitation

DATES OF GREATEST 24-HOUR PRECIPITATION

RANK OF STORM	VANCOUVER, BC	SEATTLE, WA	SALEM, OR
Greatest Precip	12 / 25 /1972	10 / 05 / 1981	11 / 18 / 1996
2	12 / 16 / 1979	11 / 23 / 1990	10 / 26 / 1994
3	10 / 16 / 1975	11 / 23 / 1986	02 / 16 / 1949
4	01 / 18 / 1968	02 / 08 / 1996	03 / 30 / 1943
5	11 / 02 / 1989	01 / 17 / 1986	12 / 02 / 1987
6	10 / 30 / 1981	11 / 25 / 1998	01 / 20 / 1972
7	07 / 11 / 1972	01 / 08 / 1990	02 / 05 / 1996
8	01 / 17 / 1986	03 / 04 / 1972	02 / 09 / 1961
9	11 / 20 / 1980	02 / 06 / 1945	01 / 03 / 1956
10th Largest	08 / 29 / 1991	11 / 19 / 1959	01 / 14 / 1974

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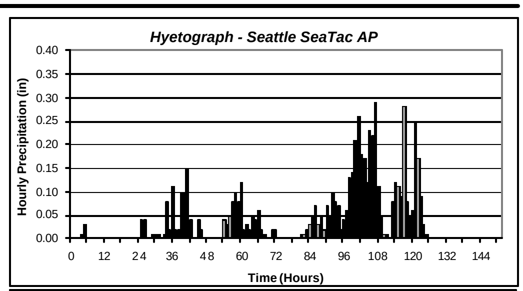
Compare *Storm of February 4-9, 1996*

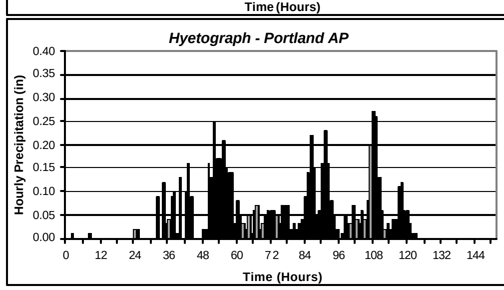
Common Storm Date

Correlated Events ??

Different Temporal Patterns



Benefit of Extended Time-Series
Diversity of Storm Temporal Patterns



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How - Extended Precipitation Time-Series

Rescale Precipitation Increments
consistent with
<u>Regional</u> Magnitude-Frequency Characteristics
for:

2-hr, 6-hr, 24-hr, 72-hr,
10-day, 30-day, 90-day, Annual Durations

Regional Magnitude-Frequency Characteristics
based on 1992 study of 150 gages in Western Washington
with 8,000 station-years of record

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Areas Covered by Extended Precipitation Time-Series …

37 Time-Series Developed

6 ETS - Vancouver WA Lowlands, 121-year, 60-min
40-inch to 60-inch MAP

18 ETS - Puget Sound Lowlands, 158-year, 60-min
24-inch to 60-inch MAP

15 ETS - Pierce County, 158-year, 15-min
38-inch to 52-inch MAP

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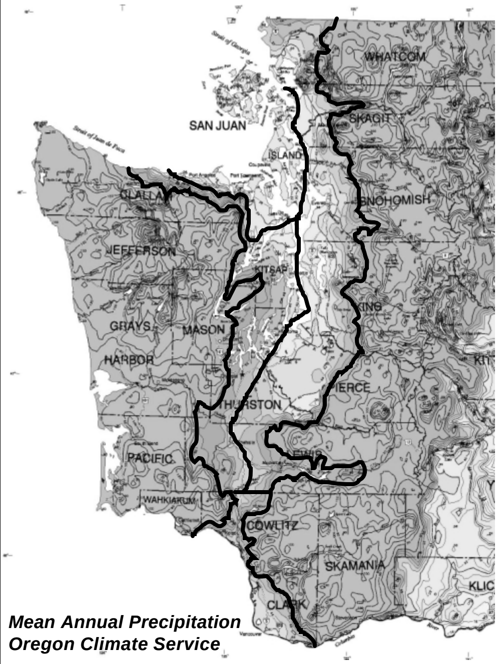
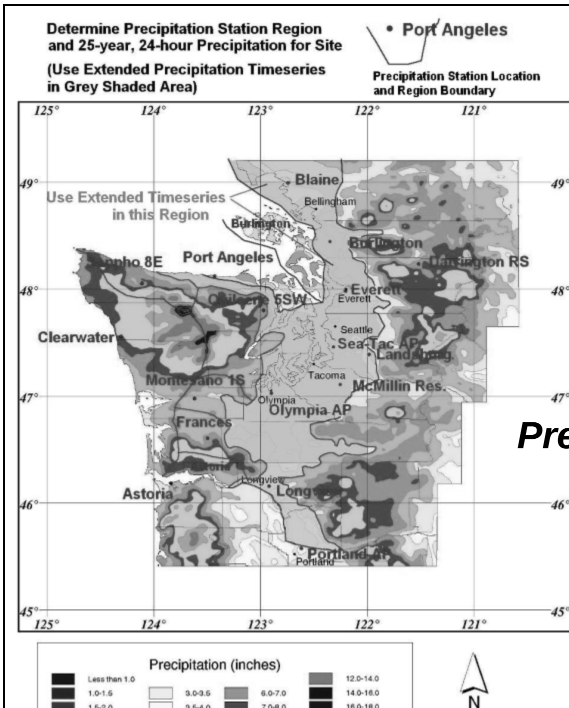


Use Extended Precipitation Timeseries Where Available

subdivided into zones of mean annual precipitation on 4-inch increments from 32 to 60-inches

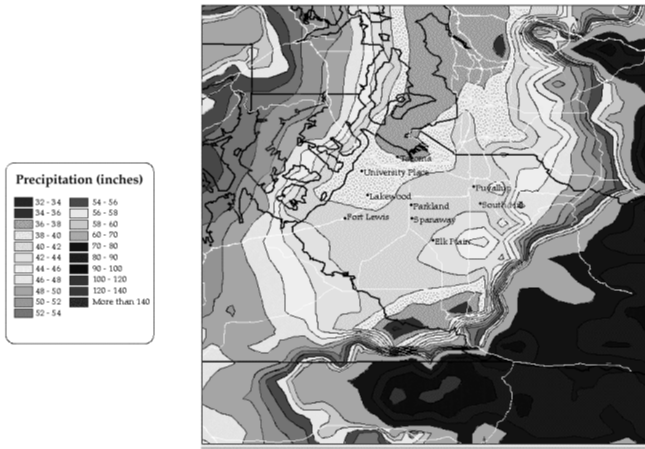
Vancouver-Centralia Area 6 time-series

Puget Sound 18 time-series separate zones West and East of Central Puget Sound



Use Station Data (Simple Scaling) Precipitation Timeseries Elsewhere

PIERCE COUNTY - 15 Separate Time-Series
One per 2-inch Zone of Mean Annual Precipitation



38 – 52 inches

Leeward / Windward

Central

Puget Sound

Mean annual precipitation is based on 1961-1990 averages, obtained using the PRISM model by Chris Daly of the Spatial Climate Analysis Service at Oregon State University. Data used in PRISM were collected at NOAA Cooperative stations and USDA-NRCS SNOTEL stations.

Use of Precipitation Time-Series in Continuous Hydrological Modeling

TRAINING TODAY

- *using extended precipitation time-series*
- *one example using simple scaling with 24-hour 25-year precipitation*

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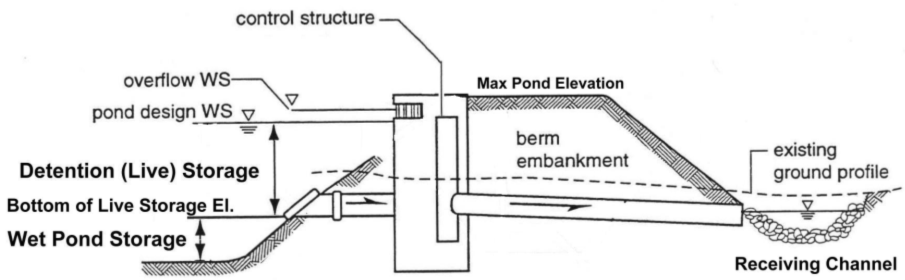
Stormwater Pond Geometry Massmann Infiltration Definitions

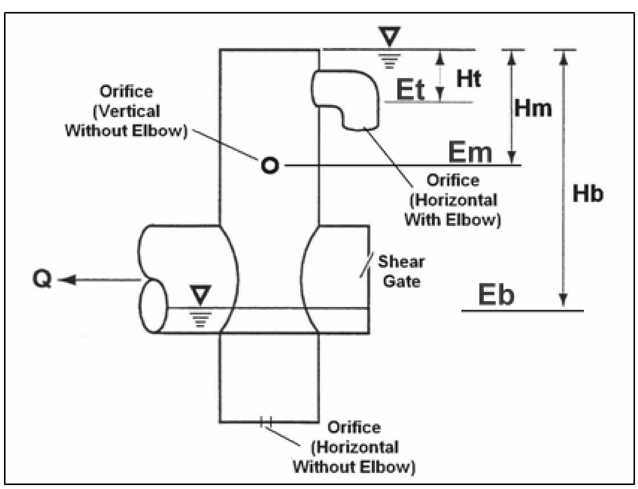
Bruce Barker, P.E.

MGS Flood Training Workshop

Typical Pond Outlet Configuration

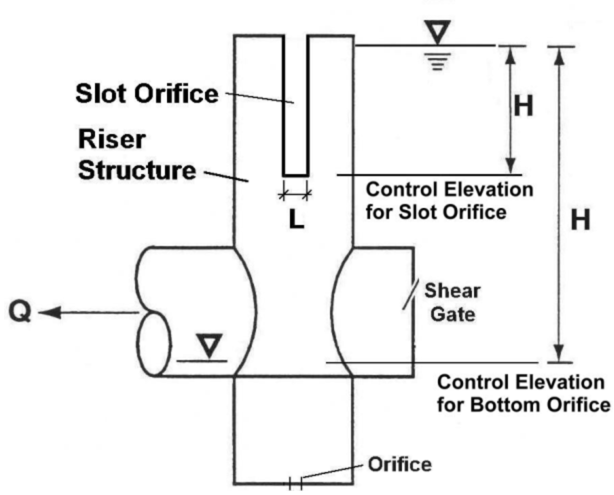


Specifying Orifice Control Elevation

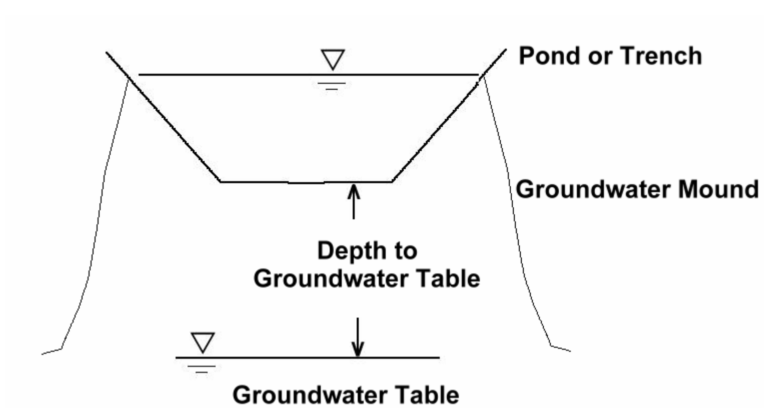


Et – Top Orifice Elevation Referenced to Elbow
Em – Middle Orifice Elevation Referenced to Orifice Centroid
Eb – Bottom Orifice Elevation Referenced to Backwater Elev
or Outlet Pipe Invert if No Backwater

Pond Control Structure Returned by Optimizer



Infiltration Definitions



(Based on Research by Joel Massmann)

Infiltration Definitions

- **Soil Hydraulic Conductivity (in/hr)** – Saturated Hydraulic Conductivity of Soil Beneath Pond (or Trench). It can be estimated using regression equations that use grain size distribution as input (Massmann) or from literature (e.g. Freeze and Cherry, Fetter)

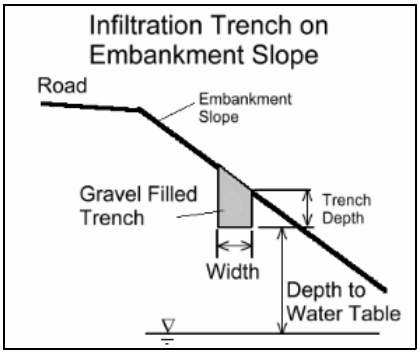
- **Depth to Regional Groundwater Table (ft)** – Depth from the Pond bottom to the groundwater table or first low-permeability layer. Upper Limit of 100-ft (no Influence for depths greater)

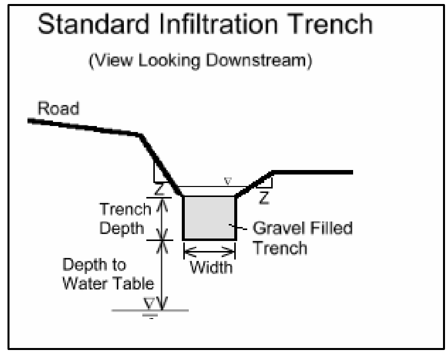
Infiltration Definitions

- **Bio-fouling Potential** – Bio-fouling occurs from organic material blanketing the soil surface and reducing the infiltration rate. Bio-fouling is more likely to occur if the pond is located beneath trees and other vegetation or in shaded locations

- **Maintenance** – The user should consider the potential for siltation of the infiltration pond and the maintenance program when determining the effects of maintenance on pond infiltration performance.

Infiltration Trench

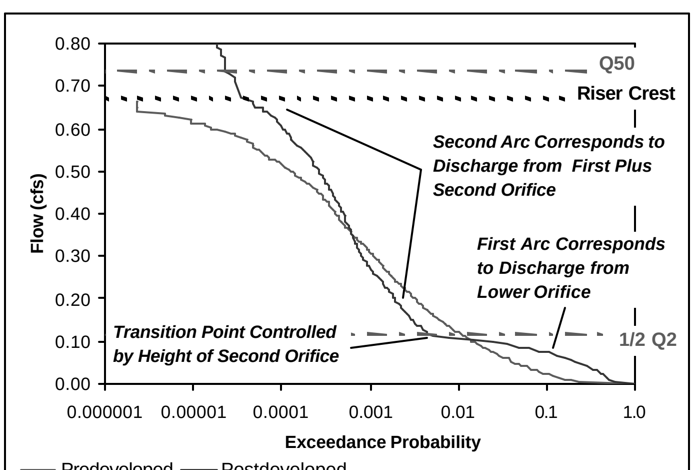




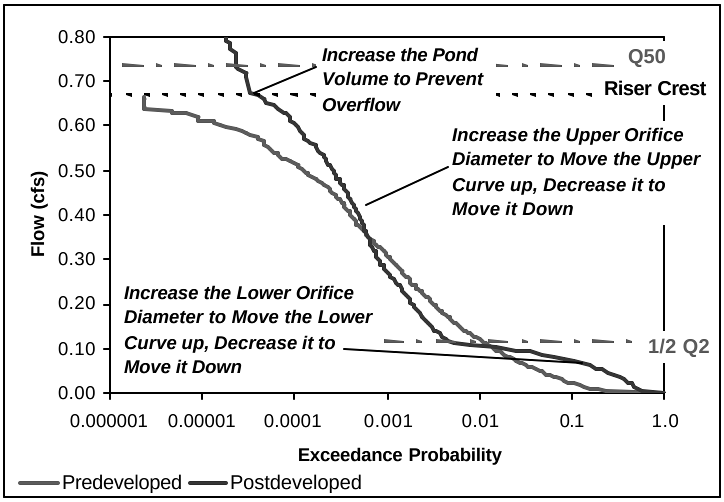
Embankment Slope Option

Standard Infiltration Trench Option

General Guidance for Manually Adjusting Pond Performance



General Guidance for Manually Adjusting Pond Performance, Continued



Stormwater Treatment

Mel Schaefer Ph.D. P.E.

MGS Flood
Training Workshop

STORMWATER TREATMENT GOALS

Treat 91% of the Annual Runoff Volume

"Treat" - interpreted by Ecology to mean:

Pass 91% of Stormwater Runoff through Treatment Process

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Wet Pool Design

Task:
Size Dead Storage Volume for Detention Pond

Solve for:

Dead Storage Volume that results in 91% of total runoff volume having retention time of 24-hours or greater

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Wet Pool Design

Ecology Proposed Method

Use Hourly Runoff Timeseries
to Compute Daily Runoff Timeseries
on midnight to midnight basis

Dead Storage Required
is the Daily Runoff Volume
at which 91% of Total Runoff Volume
is produced by Smaller Daily Volumes

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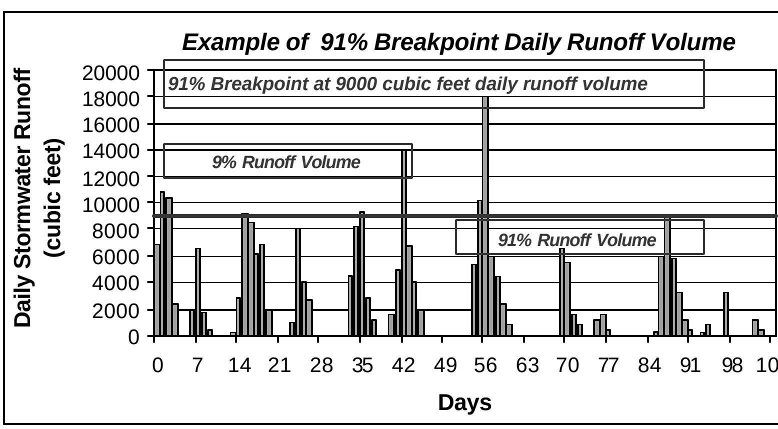
Wet Pool Design



Analysis conducted on entire daily runoff timeseries

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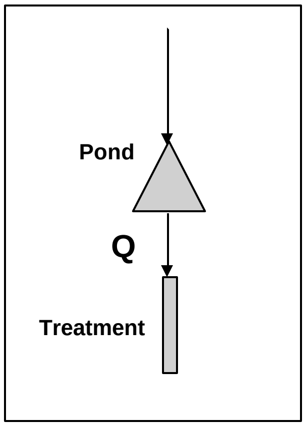
Water Quality Treatment Design Discharge Configurations



Downstream
of Detention Facility

Use Q2 Pond Outflow for Sizing Treatment

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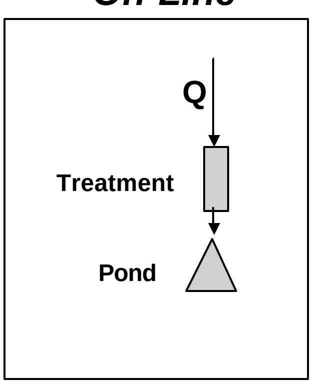
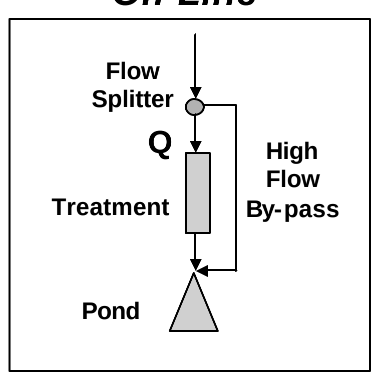
Water Quality Treatment Design Discharge Configurations

Upstream of Detention Facility

On-Line



Off-Line



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Design of Off-Line Treatment

Task:
Determine treatment rate (cfs, gpm)
for sizing off-line stormwater treatment unit

Ecology Proposed Solution:

Hourly runoff flowrate
that results in 91% of total runoff volume
being sent to off-line treatment

Convert from hourly peak rate
to 15-minute peak rate

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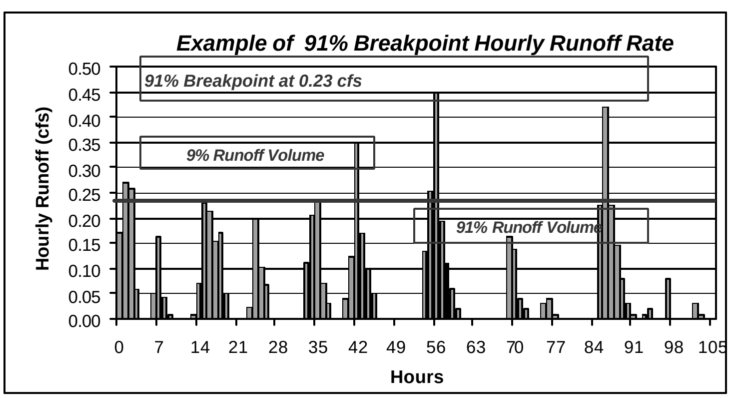
Sizing of Off-Line Treatment



Analysis conducted on entire Hourly runoff timeseries

Ecology provides "adjustment factors"
to convert from hourly to 15-minute peak rates

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Design of On-Line Treatment

On-Line Treatment is Less Effective

Ecology proposes Different Analysis
for On-Line Case
to Compensate for Poorer Performance

Result:

On-Line treatment practices
are sized to higher runoff rates
than Off-Line treatment units

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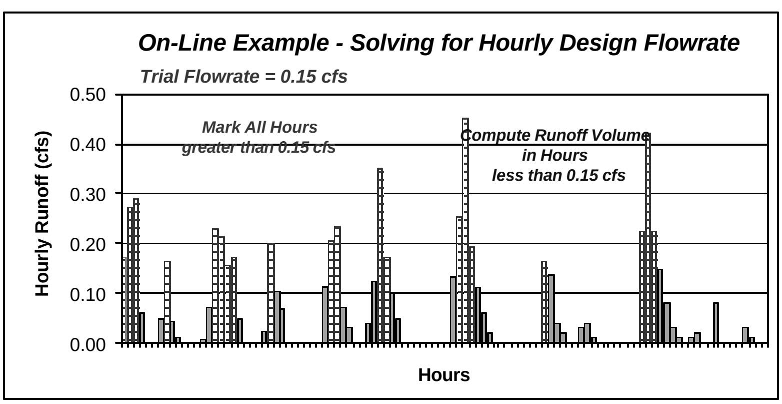
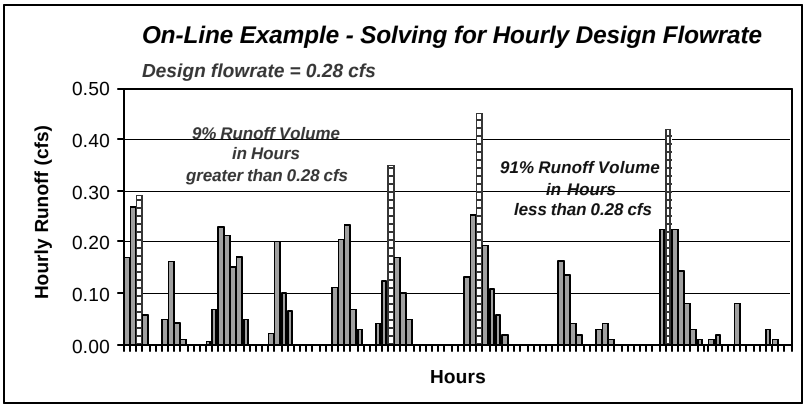
Sizing On-Line Treatment



Trial and Error Solution
No Treatment Credit in Hours Exceeding Design Flowrate
For Flowrate = 0.15 cfs
Less Than 91% of Runoff Volume Treated – Try Again!

Sizing On-Line Treatment



Analysis conducted on entire Hourly runoff timeseries

Ecology provides "adjustment factors"
to convert from hourly to 15-minute peak rates

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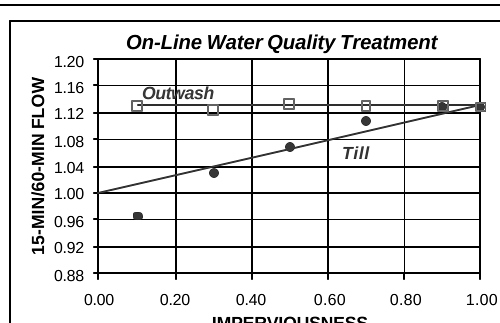
Conversion from Hourly to 15-Minute Peak Rates

New Procedures based on Analysis of Seattle 15-Minute Time-series

Conversion Factors Found to Vary from:

1.00 (Undeveloped) to 1.13 (100% impervious)

Included in MGSFlood V3



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MGSFlood Example Design Problems

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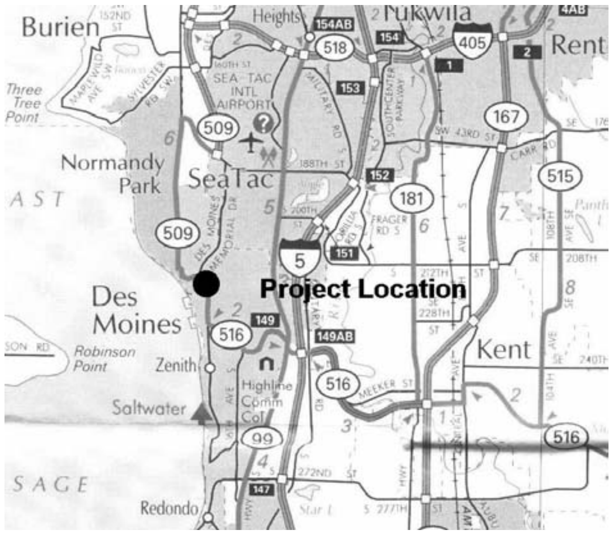
Training Workshop

MGS Flood
Example Design Problems

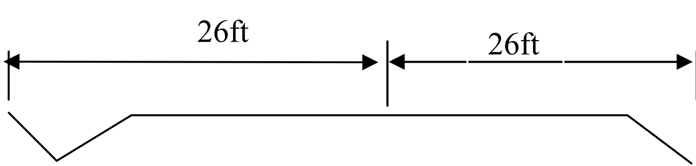
Work Session 1
Roadway Widening Problem, Manual Pond Design

A section of highway near the city of Des Moines is to be improved with an additional lane in each direction.



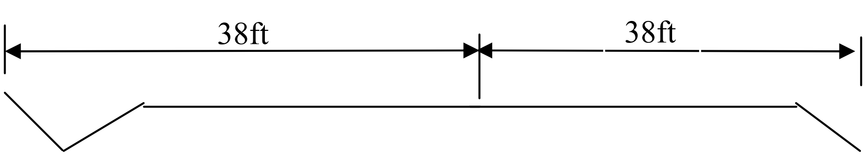
Project Location Map

The existing configuration consists of one 12-foot lane with a 6-foot shoulder on one side and an 8-foot shoulder on the other (including ditches) in each direction.



Existing Condition

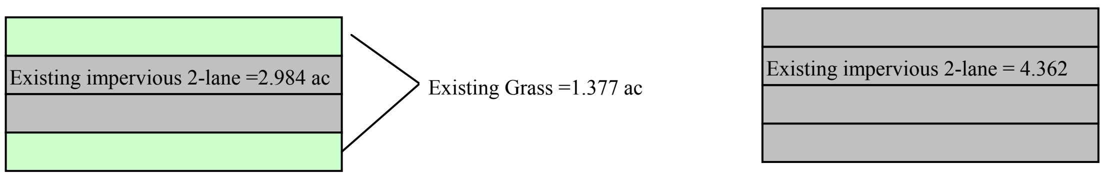
The project will add one 12-foot lane in each direction, while maintaining the current shoulder widths. Both lanes will be added on the outside of the existing lanes.



Proposed Condition

The project is located on Alderwood soils, which are classified as SCS Hydrologic Group C.

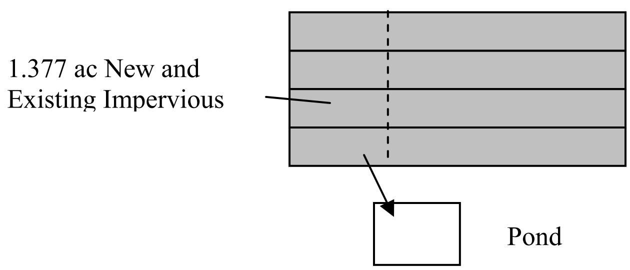
<u>Using this information, design a detention pond for this 2,500 foot section of roadway according to the HRM Equivalent Area Method. Use the *Automatic Pond Design Feature*</u> in MGSFlood <u>to Size the Pond</u>



Existing **Proposed**

Equivalent Area Representation:

- Design Pond to control runoff for conversion of 1.377 ac grass to 1.377 ac impervious.
- Direct 1.377 ac of new and existing impervious to the pond.



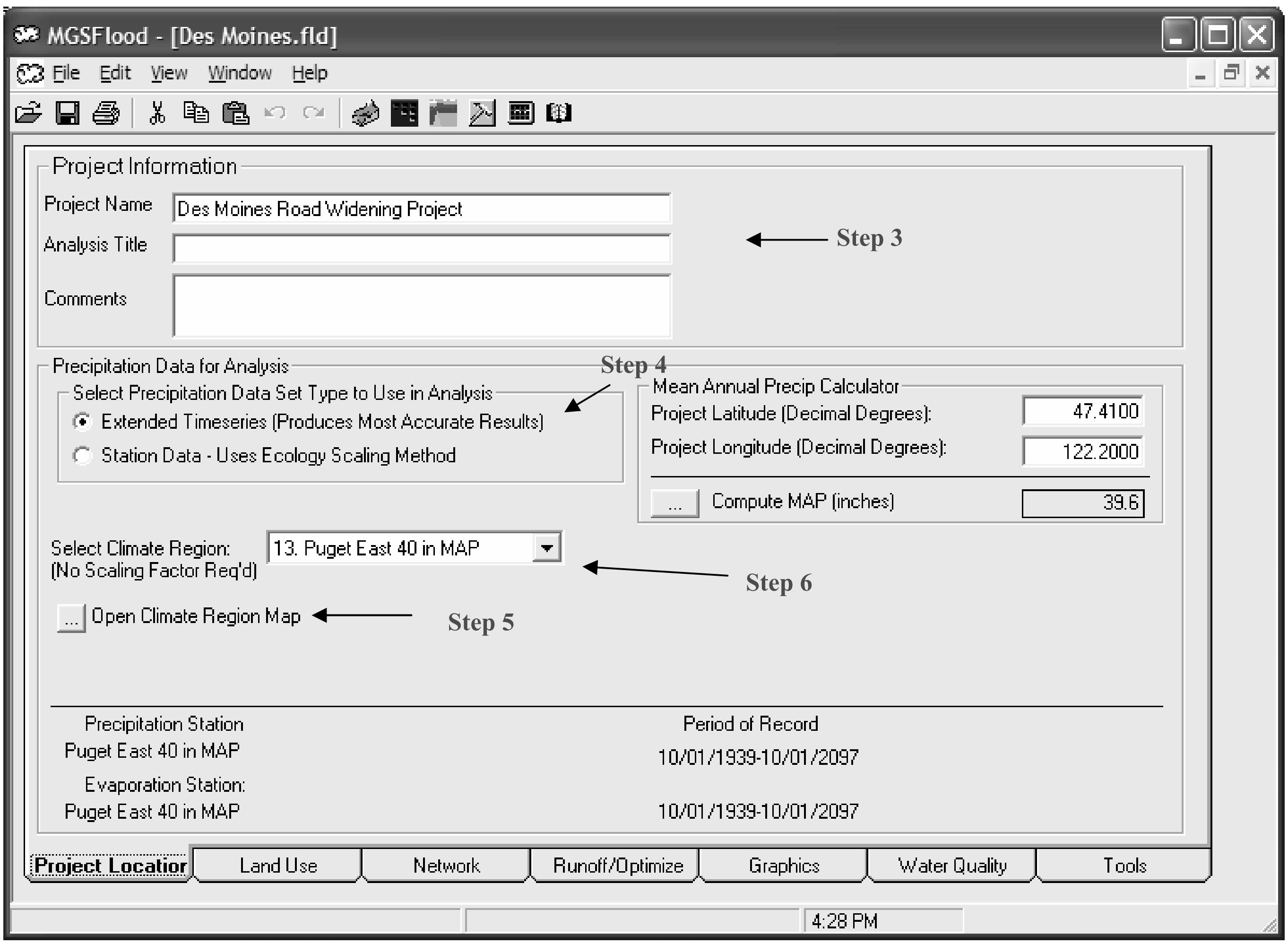
Analysis Steps

Start Program, Save Project File

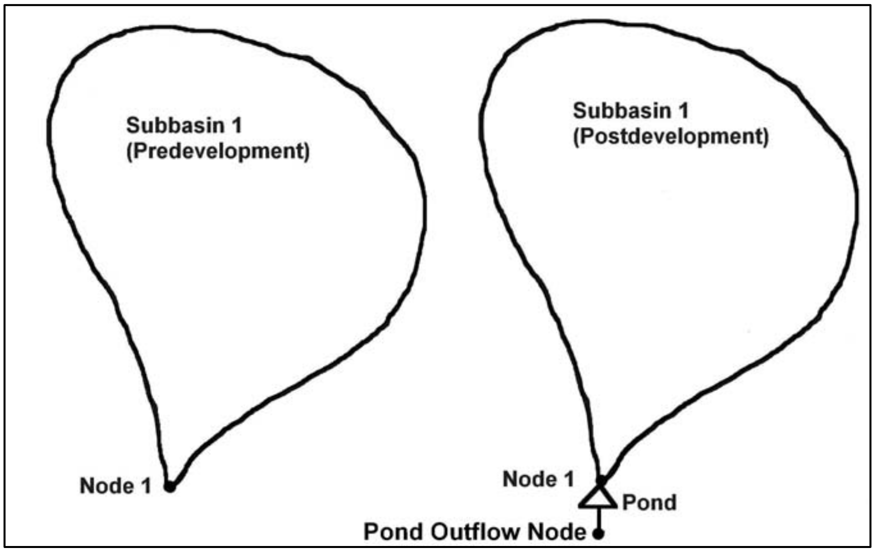
1. Start program from Windows Start button
   Start-Programs-MGS Software-MGSFlood
2. Click File Save as, Enter "Des Moines" for Project Title. Create project folder when prompted

Project Location Tab

3. Enter project name, analysis title, and comments.
4. Check the Extended Precipitation Timeseries Option Button
5. Click the *Map* button under Climate or refer to the printed copy of the map. Locate the project on the map. Note the Timeseries Region and the mean annual precipitation for the project. Click the X on the Map window to close it.
6. Select Climate Region 13 Puget East 40 in MAP from the drop down list box.



Watershed Layout Tab



7. Compute Pre- and postdeveloped area.

<u>Predeveloped:</u>

<u>Grass:</u>
New Lanes = (12’+12’)*2500’ = 60000/43560= 1.377 ac

Total predevelopment Grass: <u>1.377 ac</u>

For SCS Type C soil, use Till

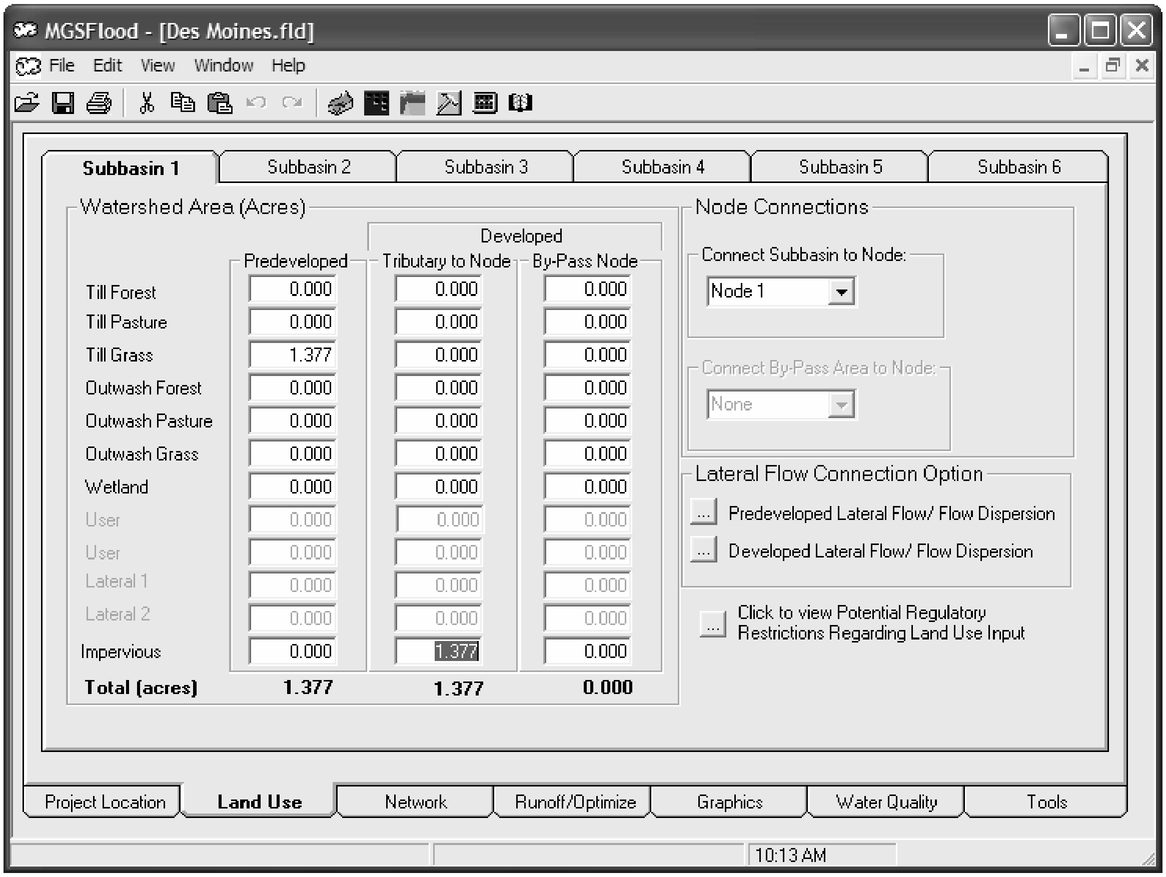
<u>Postdeveloped:</u>

<u>Developed Impervious:</u>

(12’+12’)*2500’ = 60000/43560= **<u>1.377 ac</u>**

8. Click the Land Use Tab

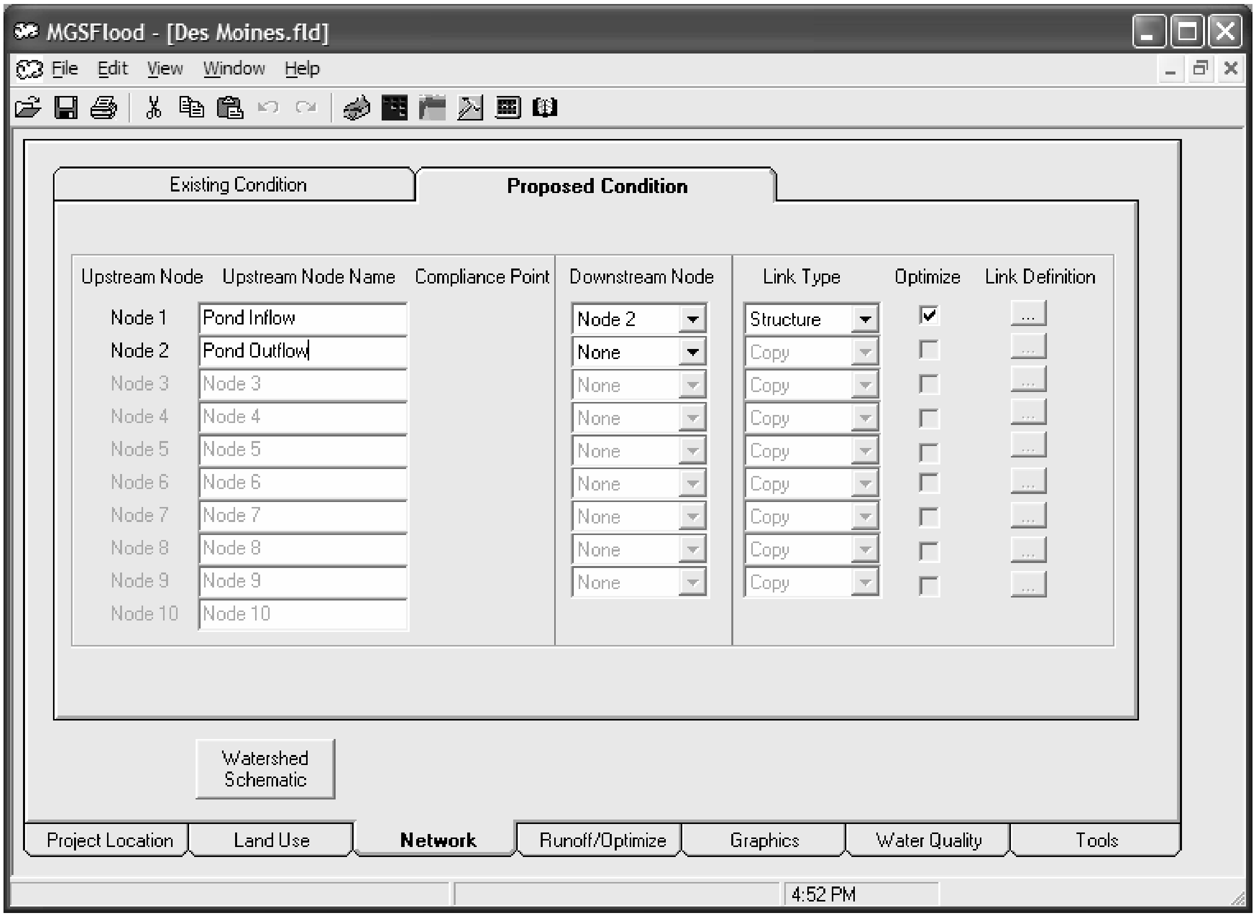
   Enter land use from above
   Connect Subbasin 1 to Node 1



9. Click the Network Tab. Enter “Compliance Point” for the Name of Node 1. No other changes are needed for the Existing Condition Scenario, Node 1 is indicated as the point of compliance.

10. Select the Proposed Condition Scenario. Enter names for Proposed Condition Node 1 and Node 2 names “Pond Inflow” and “Pond Outflow”, respectively.

11. Check the Optimize check box so that the structure (pond) will be automatically sized.



12. Click the Link Definition next to the Optimize button to define the optimization information for the structure.

Hydraulic Structures input Screens

13. Click the *Optimization* tab

14. Enter the following general information about the pond:

    a. Select *Detention* option for type of pond

    b. Pond side slope of 3H:1V

    c. Length to width ratio of 2.

    d. Pond floor elevation of 250 ft.

    e. Low Level Orifice elevation of 250 ft.

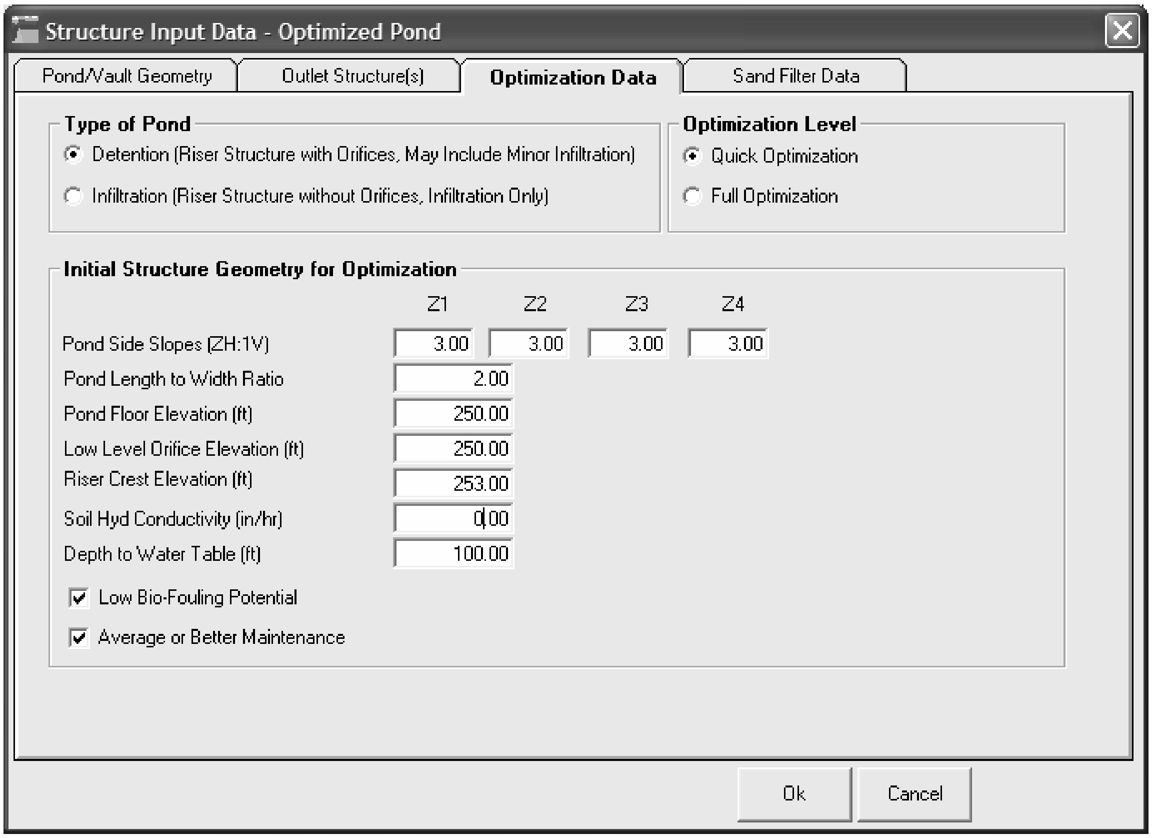
    f. Riser crest elevation of 253 ft.

    g. Soil Conductivity: 0 in/hr.

    h. Depth to Water Table: 100 ft

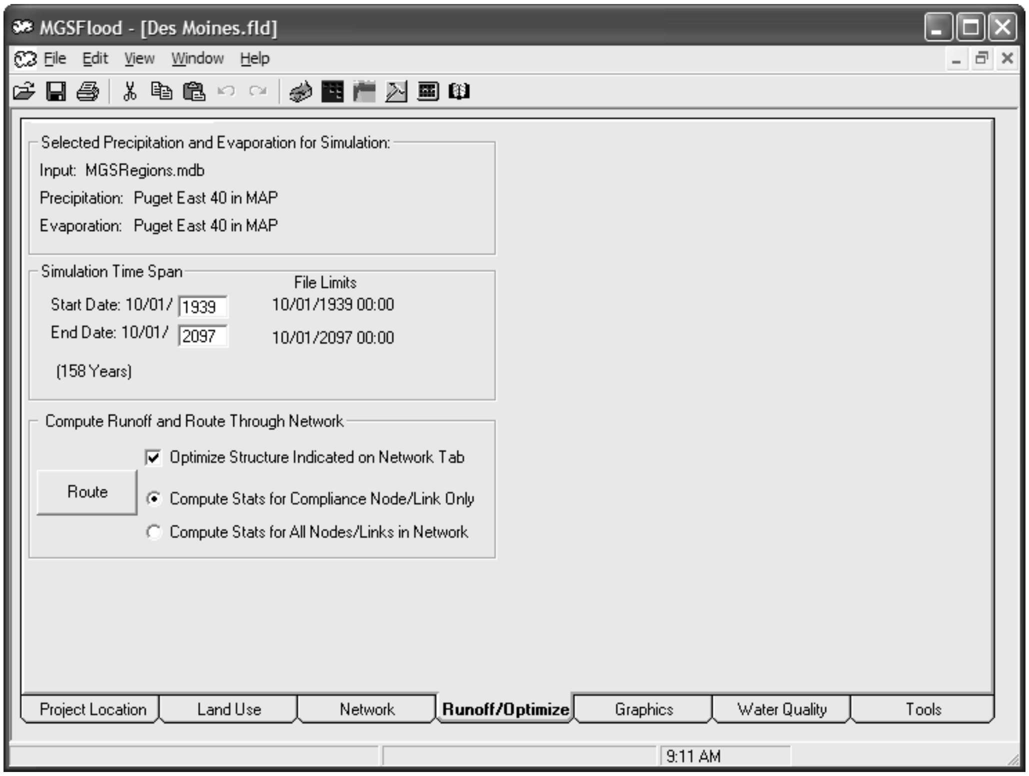
    i. Make sure Quick Optimization is selected.

15. Click OK to close the structure input screen

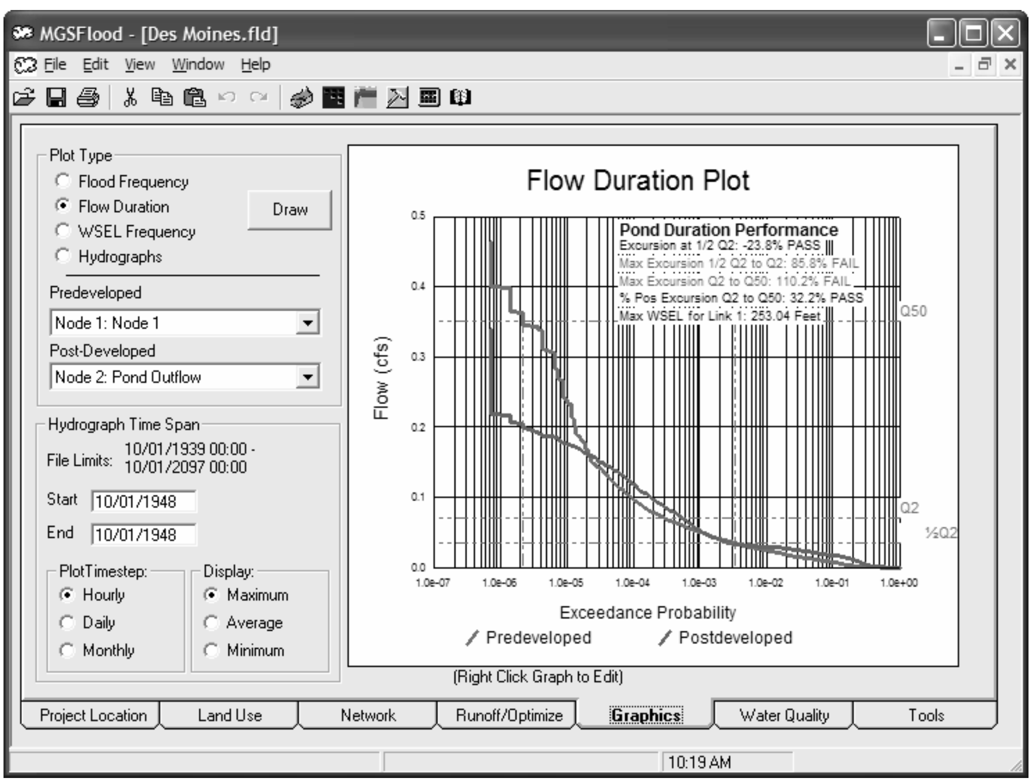


Runoff/Optimize tab

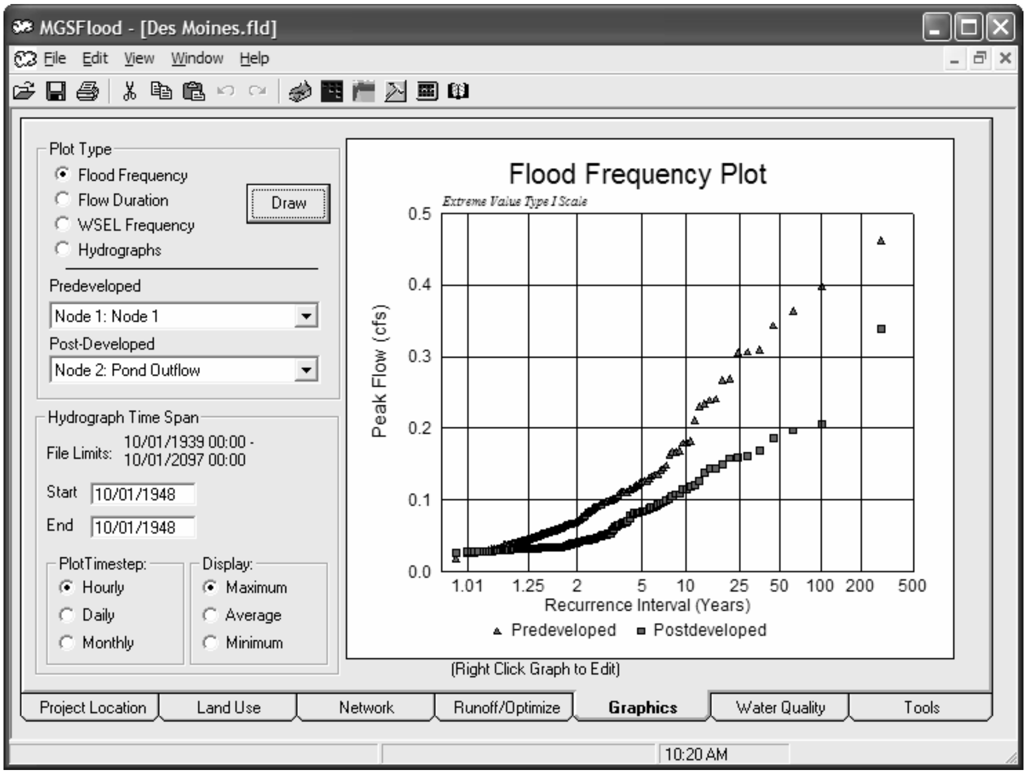
15. *The Simulation Time Span* is set to the full period of record of precipitation. No changes here.
16. Compute runoff for the full period of record. Click the *Run* button.
17. Check the Optimize Structure Indicated on Network Tab box
18. Check the Compute Stats for Compliance Node/Link Only box
19. Click the Route button to simulate runoff, route flows through the network, and automatically size the pond.

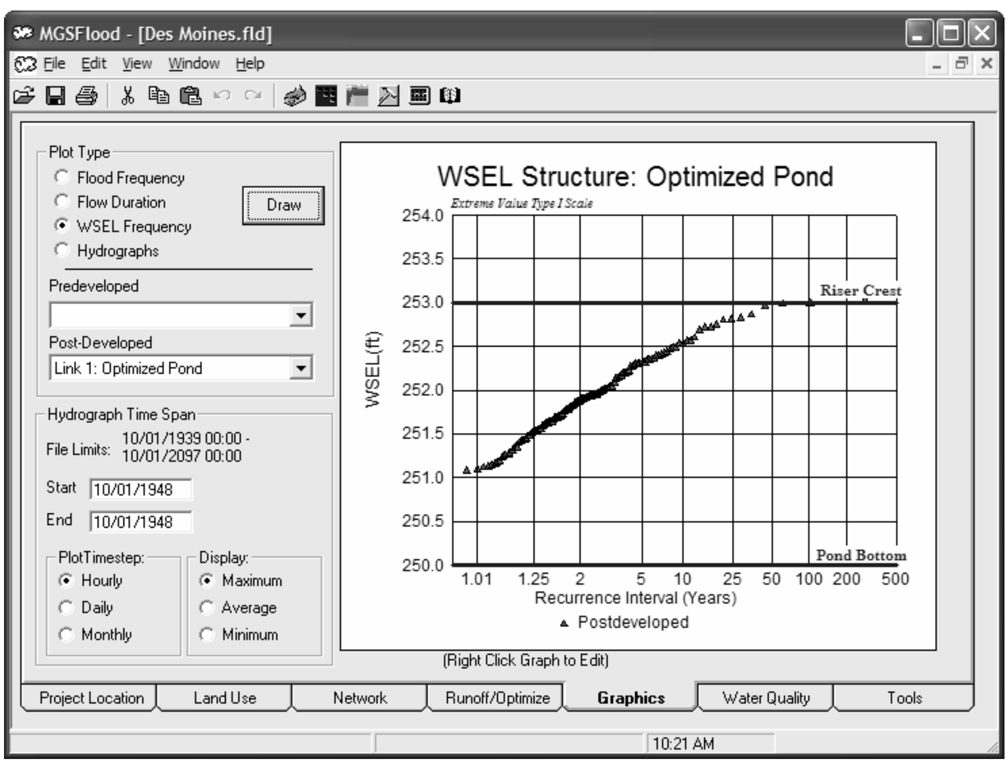


When the simulation is complete, the pond performance will be displayed.

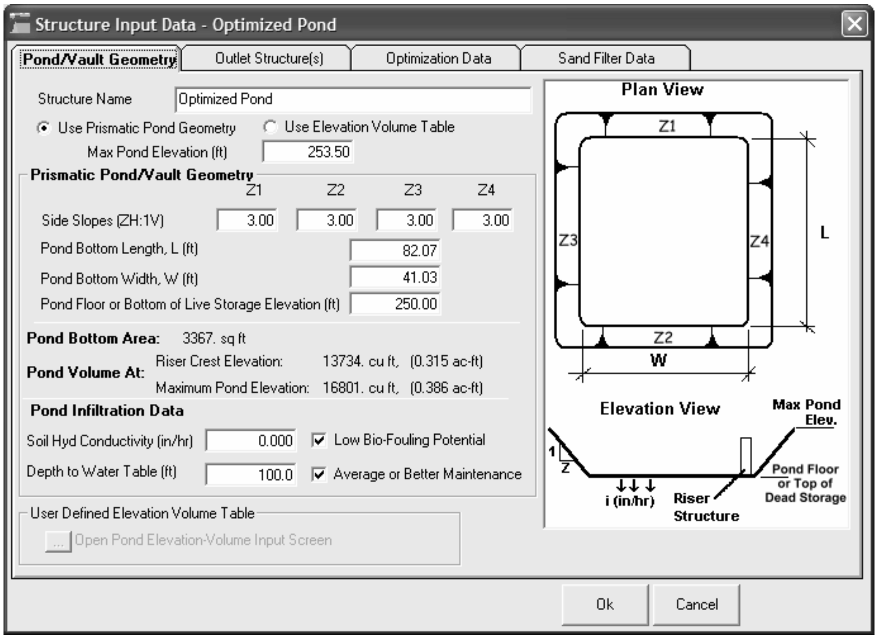


Select flood frequency and WSEL frequency to view flood and water surface elevation plots, respectively.





20. Click the *Network* tab, reopen the Structure (Pond) *Link Definition* Screen.
The resulting pond geometry and outlets are displayed on the Pond Vault Geometry and Outlet Structure tabs.

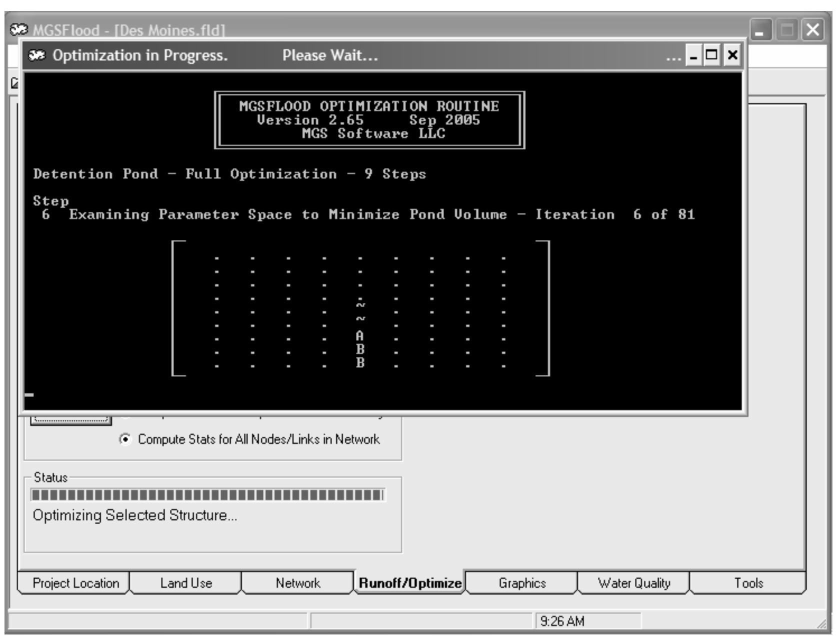


21. Click the *Optimization* tab, Select **Full Optimization**, then click OK to close the Structure Input Window

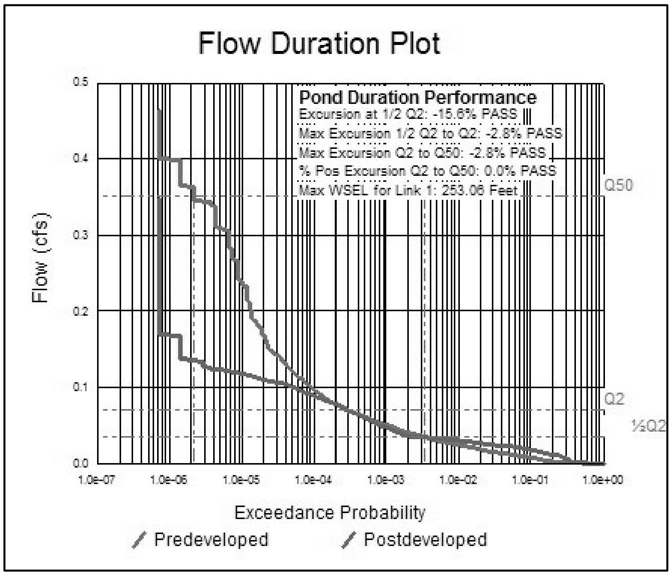
22. Click the Runoff/Optimize tab

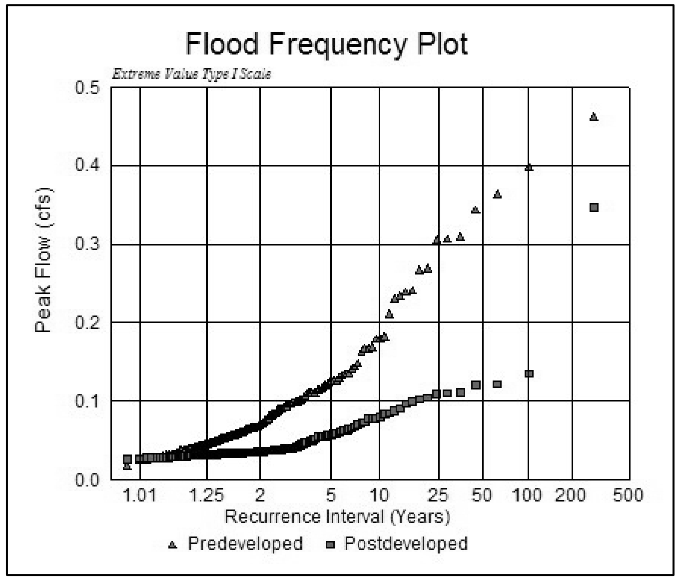
23. Check the Compute Stats for all Links/Nodes in Network box

24. Click the Route button to simulate runoff, route flows through the network, and automatically size the pond.



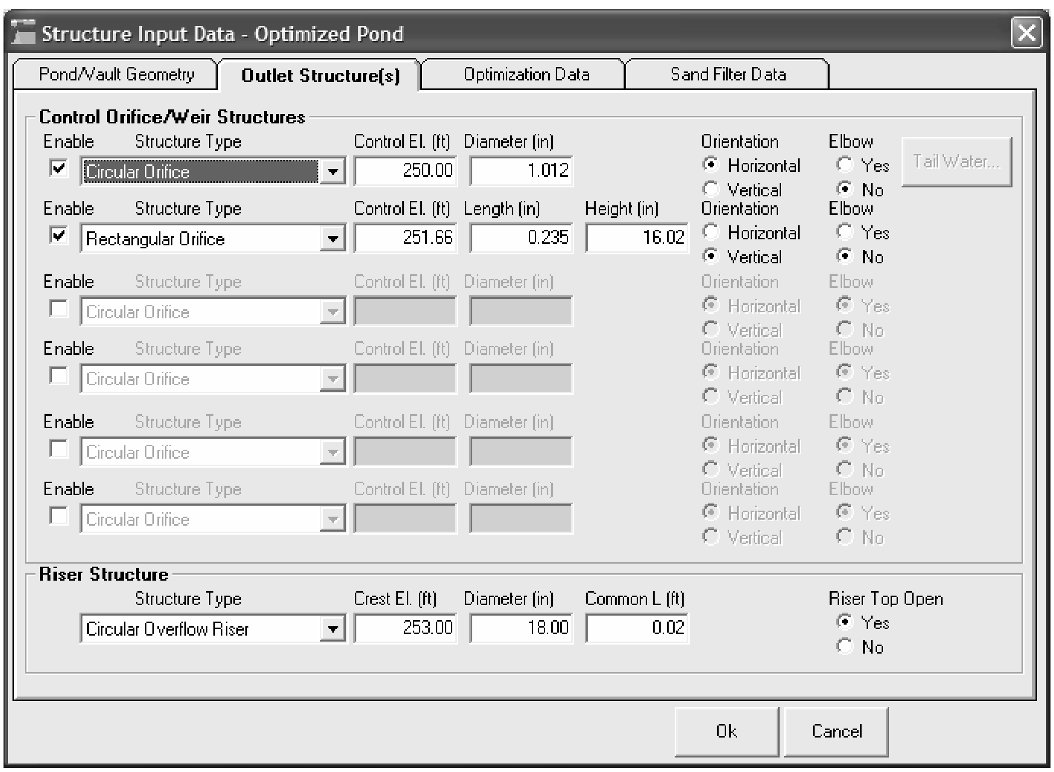
25. Check the *Flood Frequency* option button and then the *Draw* button to plot the flood peak performance.





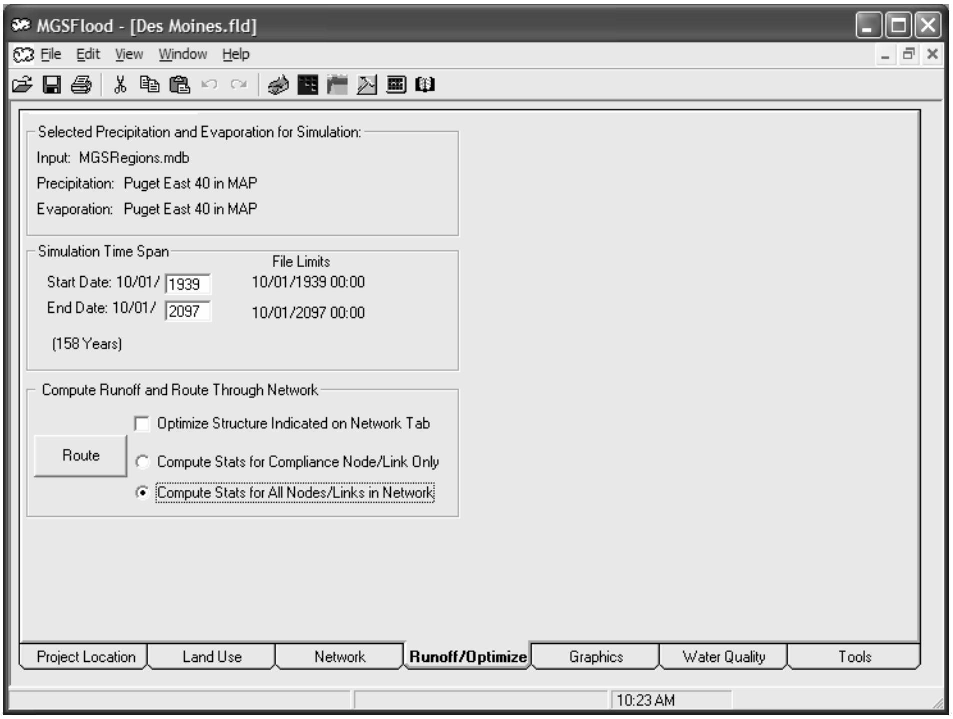
26. Click the *Network* tab, reopen the Pond *Link Definition* Screen, Click the Outlet Structure(s) Tab

27. Increase the Slot Orifice Length to 0.25" (the minimum acceptable Length)



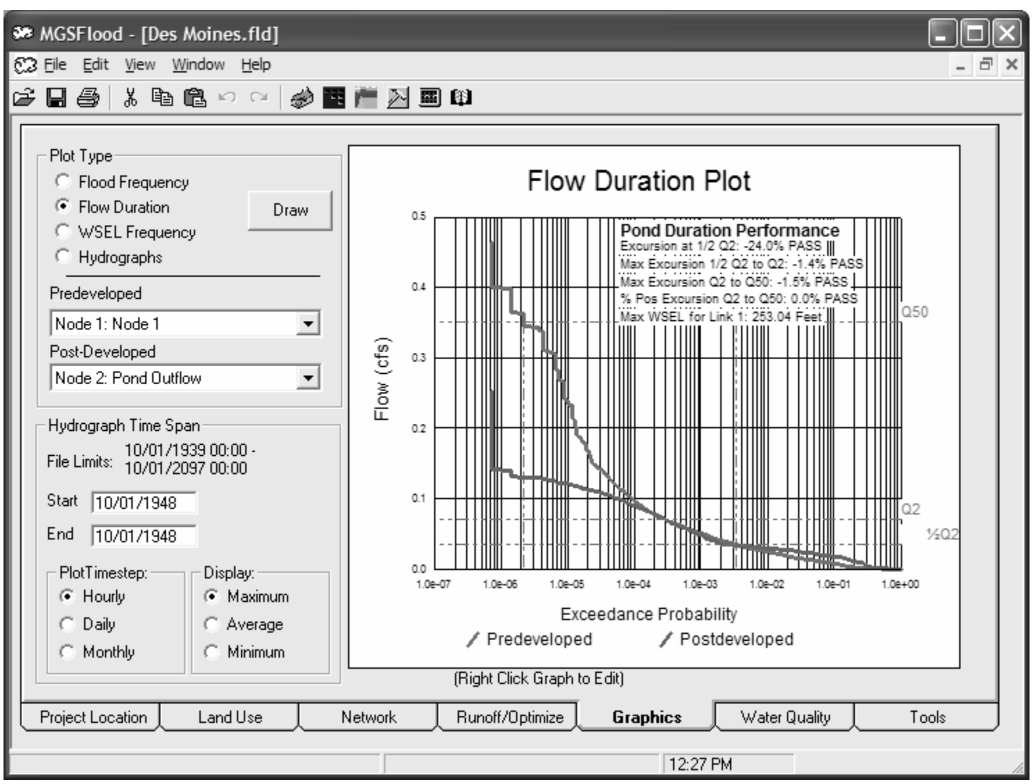
28. Click the OK button.

29. Click the Runoff/Optimize Tab. <u>Uncheck</u> the Optimize Structure checkbox

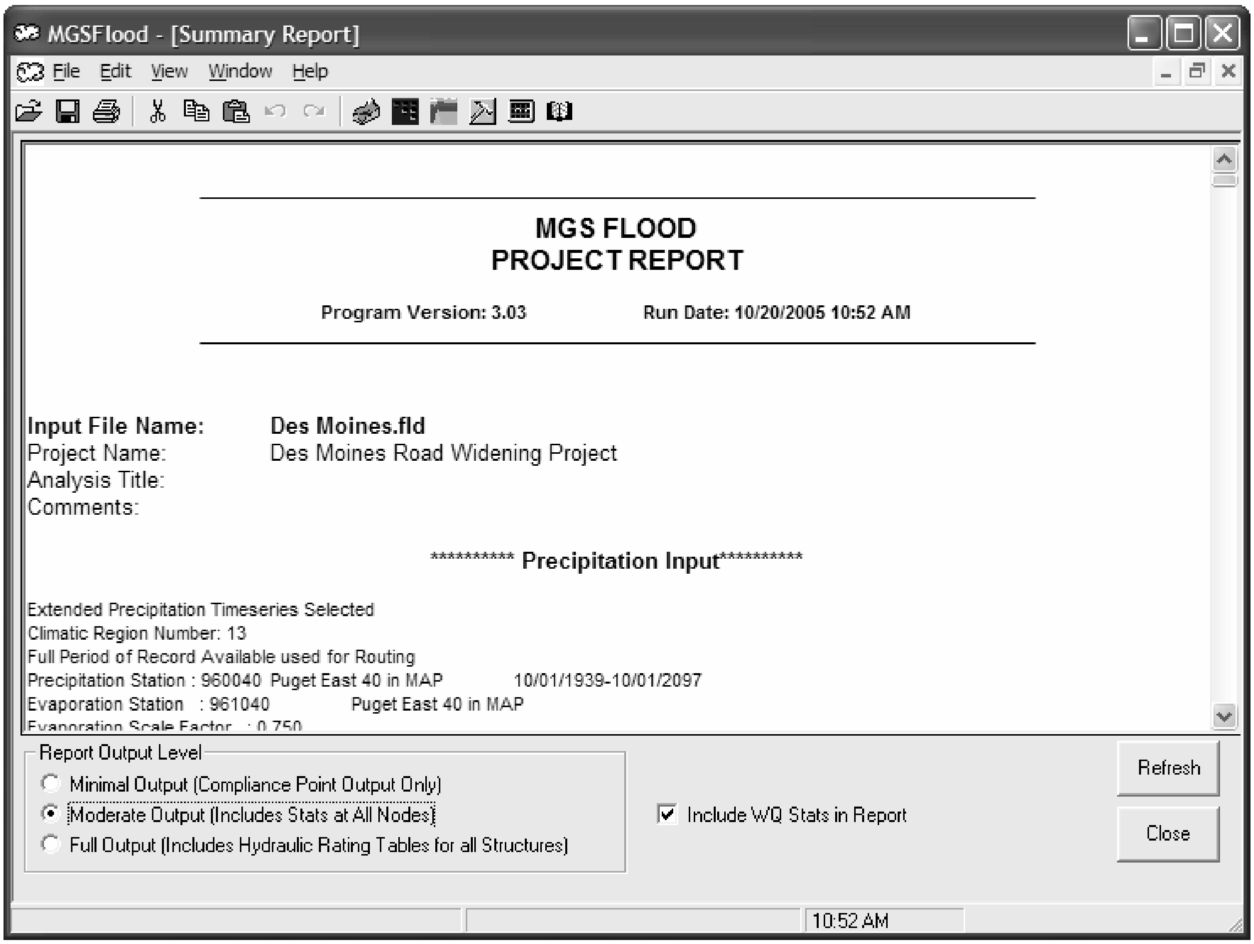


30. Click the *Route* button with the compute stats for all Nodes/Links box checked. The resulting pond performance fails.

31. Increase the Pond Length to 90 ft and the width to 45 ft. Route flows. The pond meets the required performance.

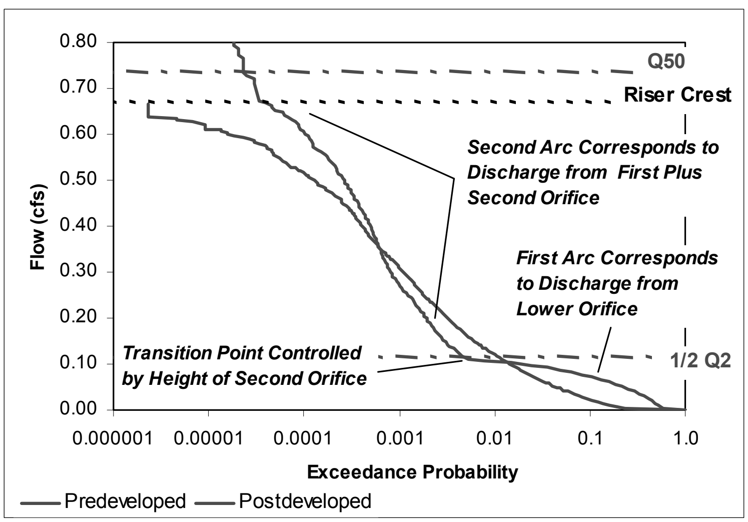


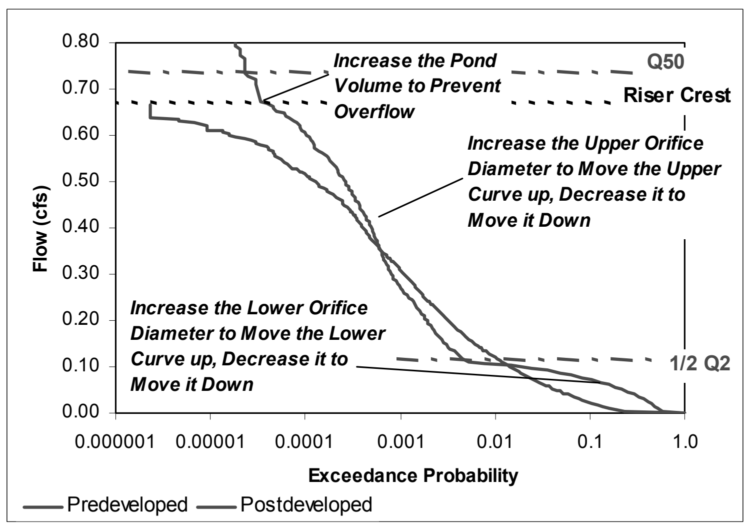
32. Open the Structure Link. Change the Pond Length and Width to 89' and 44', respectively.
33. Click the OK button.
34. Click the *Route* button with the compute stats for all Nodes/Links box checked
35. When finished, view documentation report either from the *File-Print* menu, from the icon on the tool bar, or by opening the .rtf file with a word processor. Any graphs created during the analysis are stored in jpeg files in the project subdirectory.



General Guidance for Adjusting Pond Duration Performance

- Analyze the duration curve from bottom to top, and adjust orifices from bottom to top.
- The bottom arc corresponds with the discharge from the bottom orifice. Reducing the bottom orifice discharge lowers and shortens the bottom arc while increasing the bottom orifice raises and lengthens the bottom arc.
- Inflection points in the outflow duration curve occur when additional structures (orifices, notches, overflows) become active.
- Lowering the upper orifice moves the transition right on the lower arc and raising the upper orifice moves the breakpoint left of the lower arc.
- The upper arc represents the combined discharge of both orifices. Adjustments are made to the second orifice similar to the bottom orifice.
- Increasing the facility volume moves the entire curve down and to the left. This is done to control riser overflow conditions. Decreasing facility volume moves the entire curve up and to the right.

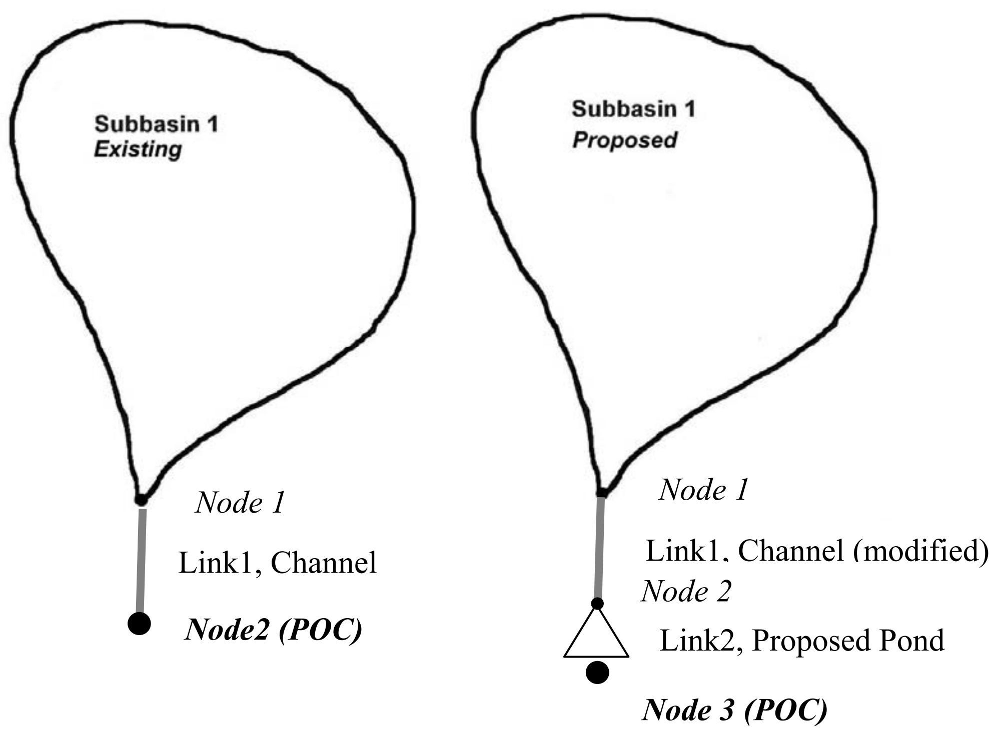




Work Session 2 and 3
Roadway Widening Problem, Multiple Link Example, Infiltration Pond Automatic Pond Design

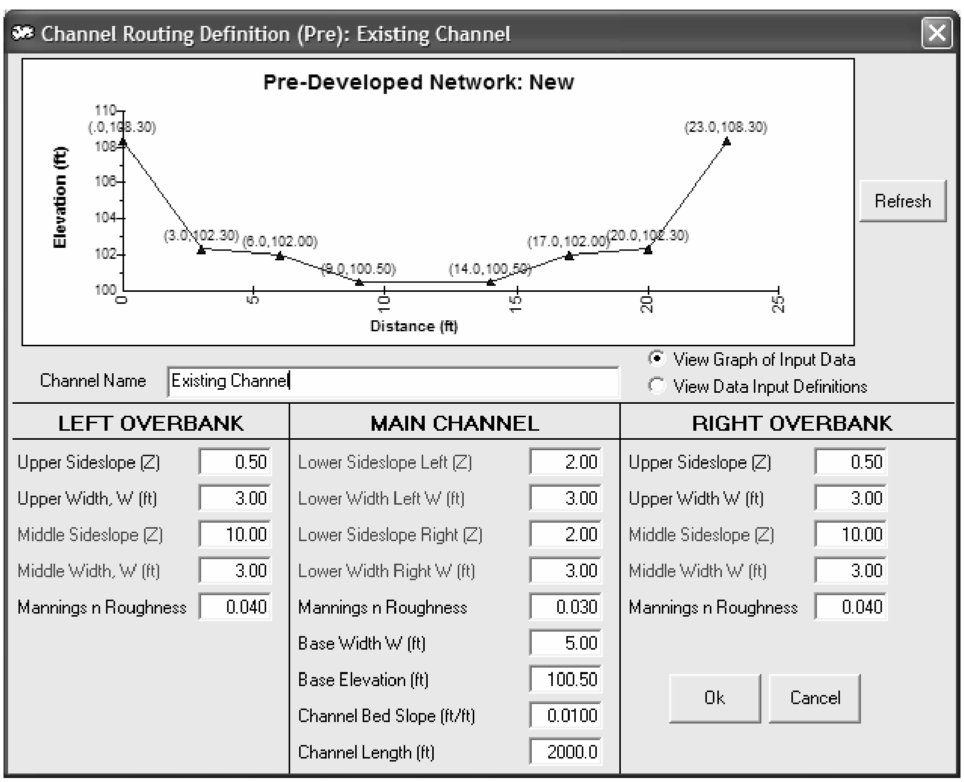
For the Work Session 1 problem, include a drainage swale upstream of the compliance point will be modified as part of the road widening project. The cross sectional area of the swale will be reduced. Include the pre- and Post-developed drainage swales and design a detention pond using the quick optimization method. Assume the same land use conditions as the previous example.

The pre- and postdeveloped watershed configuration will be as follows:

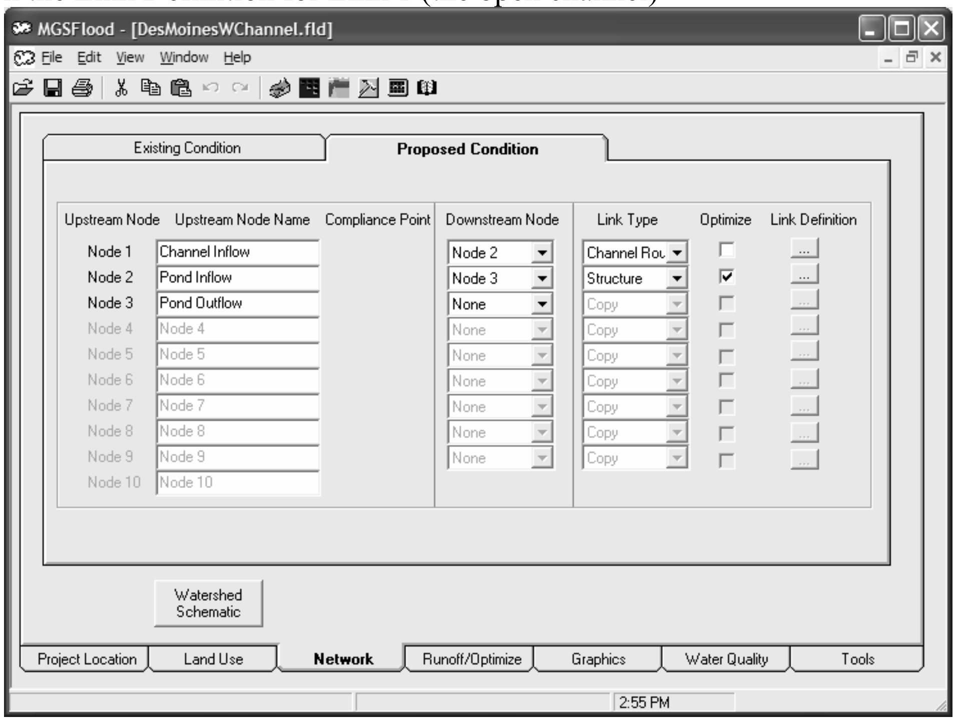


1. Open the input file from the previous example (if it's not already open).
2. Click the Network Tab and select the Existing Condition Scenario tab.
3. Connect Node 1 to Node 2 and Select Node 2 as the Point of Compliance (POC)
4. Define Link 1 as a structure, and open the Link Definition Window.

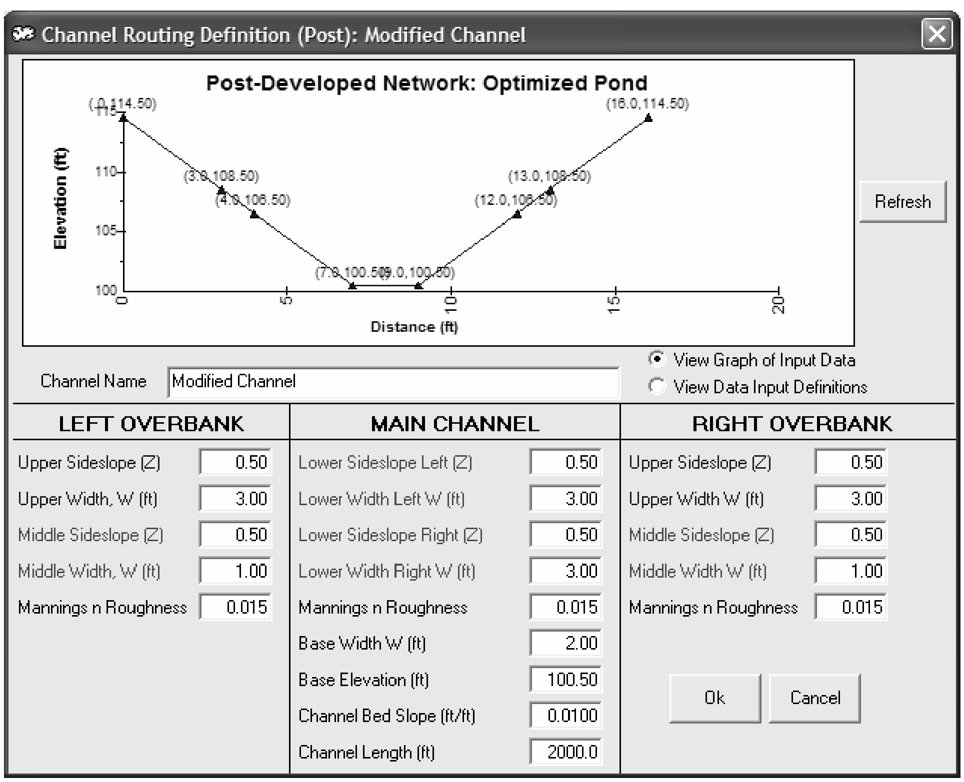
5. Enter the stream channel geometry information as shown below. Click the Refresh button to update the channel cross section. Click OK when finished.



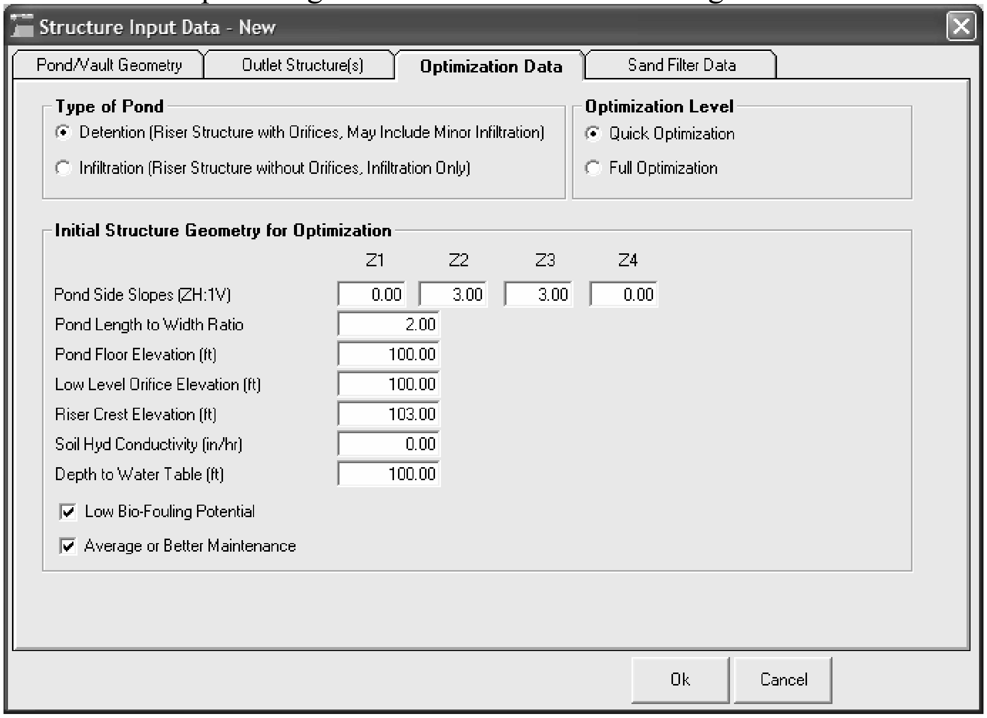
6. Click the Proposed Condition tab. Connect Node 2 to Node 3. Change Link 1 to Open Channel. Define Link 2 as a structure. Check the Optimize Box for Link 2.
7. Open the Link Definition for Link 1 (the open channel)



6. Enter the stream channel geometry information as shown below. Click the Refresh button to update the channel cross section. Click OK when finished.

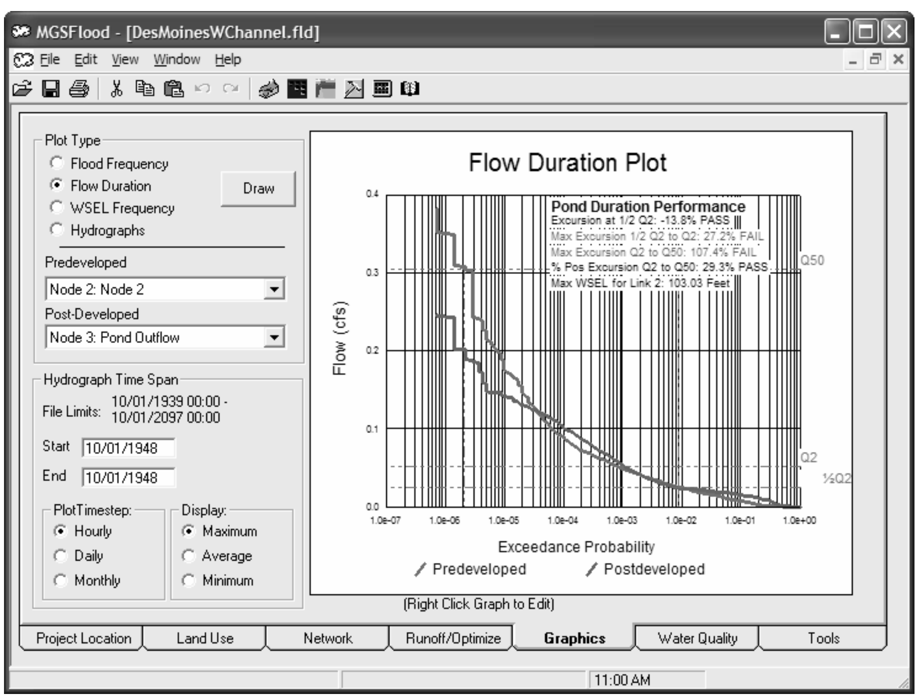


7. Open the Link Definition for Link 2 (the pond). Click the Optimization tab. The pond will have vertical side-slopes along two sides. Enter the following information and click OK:



8. Click the Runoff/Optimize tab. Make sure the Optimize and Compute Stats for All Nodes/Links in Project are checked. Click the Route button.

9. View Flood Peak and Duration Graphs for all nodes in project.

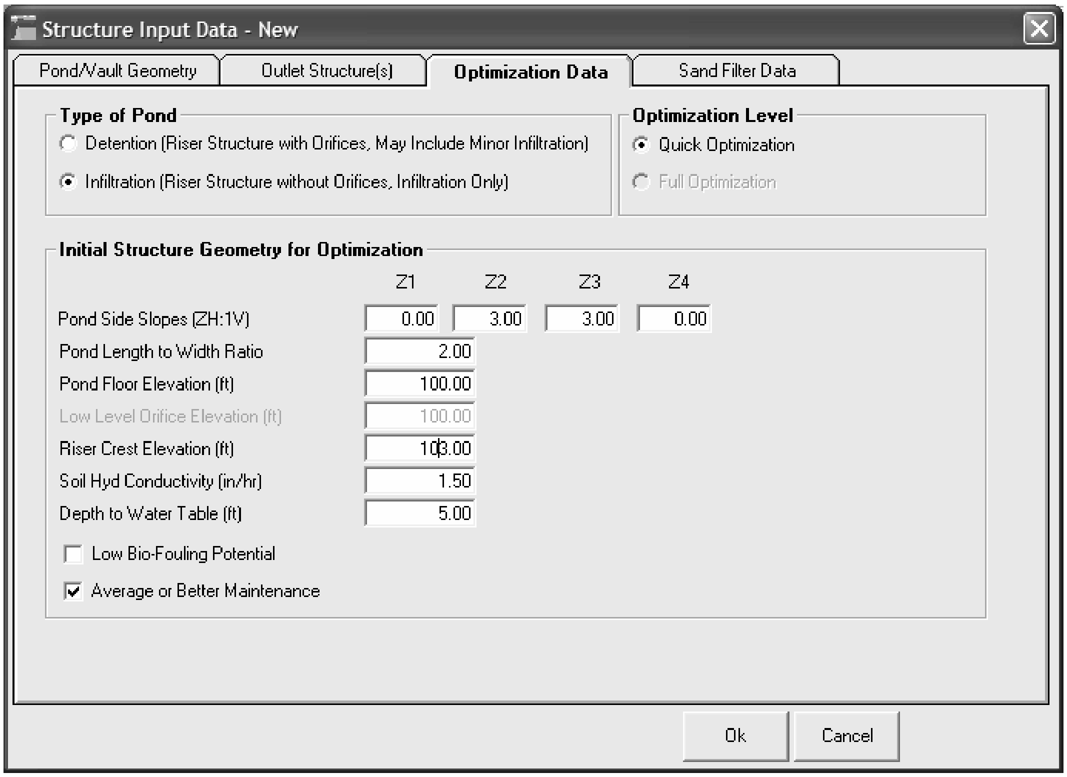


Work Session 3 – Infiltration Pond

(Review Massmann Infiltration Approach)

Replace the previous detention pond with an infiltration pond. Use the Optimization routine to size the pond.

1. Click the Network Tab and select the Proposed Condition Scenario tab.
2. Open the Link 2 Definition Window. Click the Optimization tab. Define the following infiltration pond information.



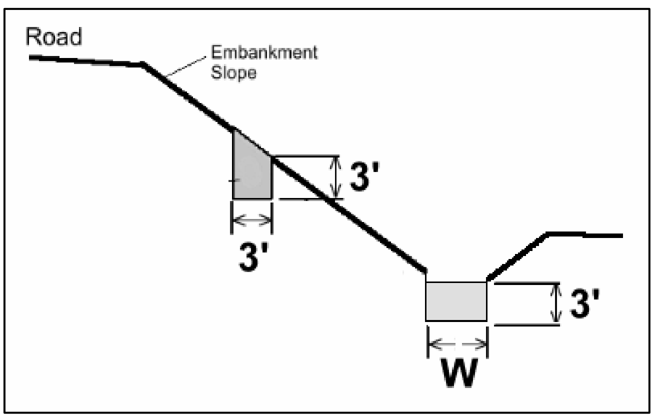
3. Click the Runoff/Optimize tab. Make sure the Optimize and Compute Stats for All Nodes/Links in Project are checked. Click the Route button.
4. Note the Pond Volume Achieved.
5. Use the Optimizer to size a pond with a depth to groundwater of 50 feet. Click the Low Bio-fouling Potential button and resize the pond.

Work Session 4
Off Ramp Design, WSDOT Highway Runoff Manual Infiltration Trench Design

A new off-ramp is being constructed near Vancouver. The existing condition consists of grass right of way. The off-ramp will be 1,000 feet long and 28 feet wide pavement and 10' wide grass slopes. The ramp will be sloped such that all runoff discharges to one side of the ramp. Geologic investigations indicate permeable alluvium soil with characteristics similar to outwash.

Design an infiltration trench system that meets the flow duration standard for this project.

Include an embankment infiltration trench 3' wide and 3' deep. Also include a standard infiltration trench at the base of the embankment to infiltrate any water not infiltrated in the embankment slope trench. Use side slopes of 1.5H:1V for this trench. Geologic investigations indicate minimum depth to groundwater of 15 feet below the upper trench and 10 feet below the lower trench during the winter months. Assume that the embankment trench is located half way down the slope. Use saturated hydraulic conductivity of 1 inch per hour for native material and a porosity of 30% for the trench gravel.



Problem 4 Trench Configuration

Start Program, Save Project File

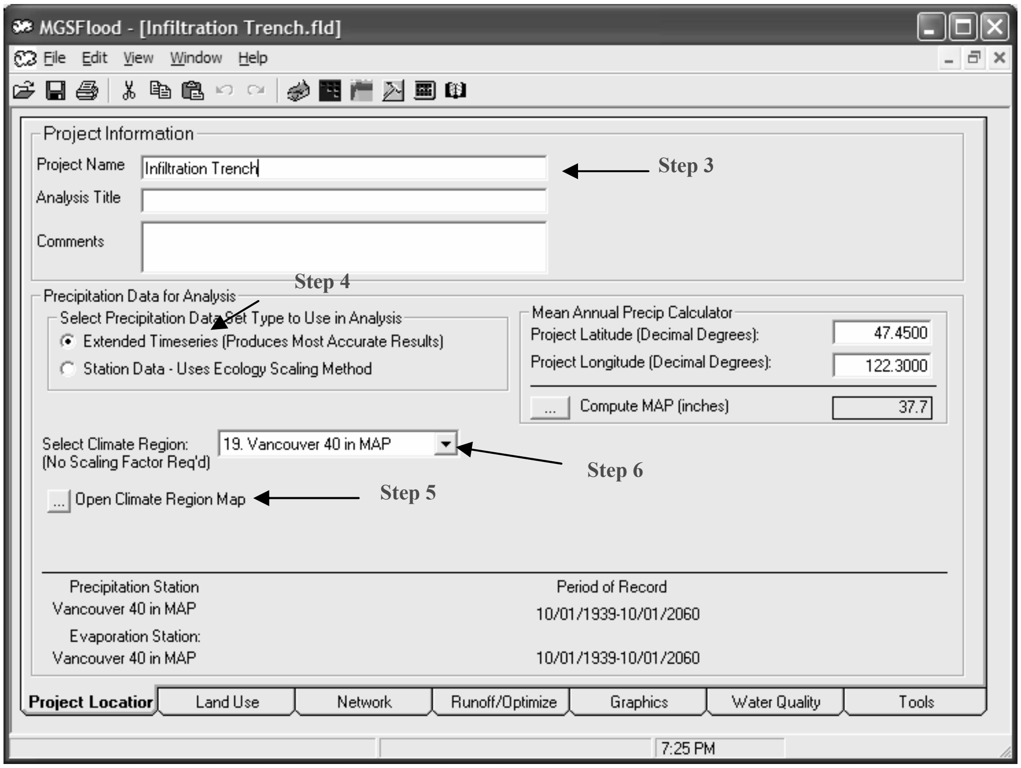
1. Start program from Windows Start button
2. Click File Save as, Enter "InfiltrationTrench" for Project Title. Create project folder when prompted.

Project Location Tab

3. Enter project name, analysis title, and comments.
4. Check the Extended Precipitation Timeseries Option Button
5. Click the *Map* button under Climate or refer to the printed copy of the map. Locate Vancouver on the map. Note the Timeseries Region and the mean annual precipitation for

the project. Click the X on the Map window to close it. You could also use the calculator to determine the Mean Annual Precipitation for the project site.

6. Select Climate Region 19. Vancouver 40 in MAP from the drop down list box.



Land Use Tab

The pond will be designed for the mitigated (new impervious) area only. Subbasin 1 consists of the new impervious area and Subbasin 2 consists of the remaining area discharging to the pond.

7. Compute Pre- and postdeveloped area.

Subbasin 1: Area Draining to Embankment Trench

Predevelopment

Outwash Grass:
(28'+5')*1000'=33,000/43560 = **0.758 ac**

Post-Development

Impervious:
28'*1000'=28,000/43560 = **0.643 ac**

Till Grass (Road Embankment)
5'*1000'=5000/43560=**0.115 ac**

Subbasin 1 Total: 0.758 acres

Subbasin 2: Area Draining to Standard Trench

Predevelopment

Outwash Grass:
5'*1000'=5000/43560=**0.115 ac**

Post-Development

Till Grass (Road Embankment)
5'*1000'=5000/43560=**0.115 ac**

Subbasin 2 Total: 0.115 acres

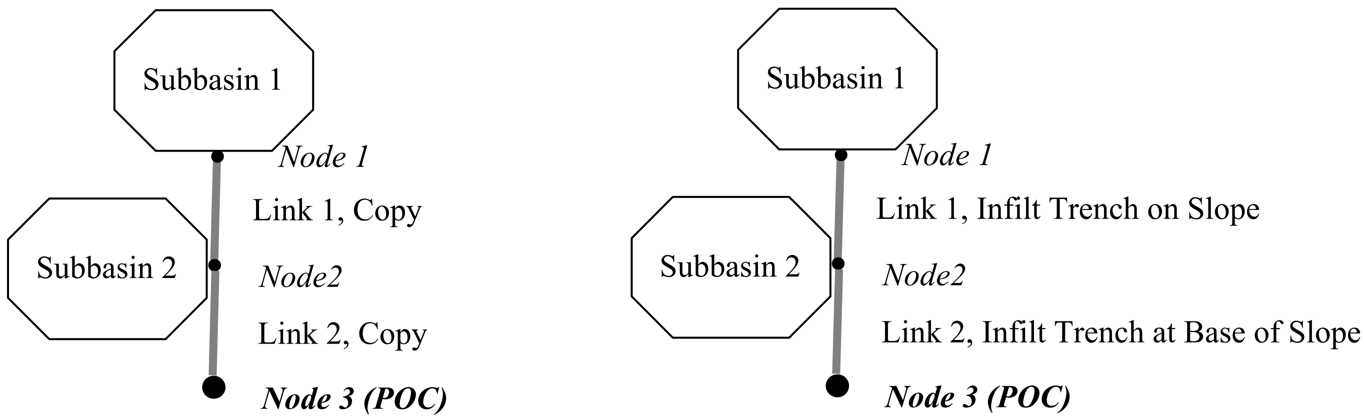
Subbasin 1+2 Total: 0.873 acres

8. Enter land use from above for Subbasin 1 then Subbasin 2. Connect Subbasin 1 to Node 1 and Subbasin 2 to Node 2.

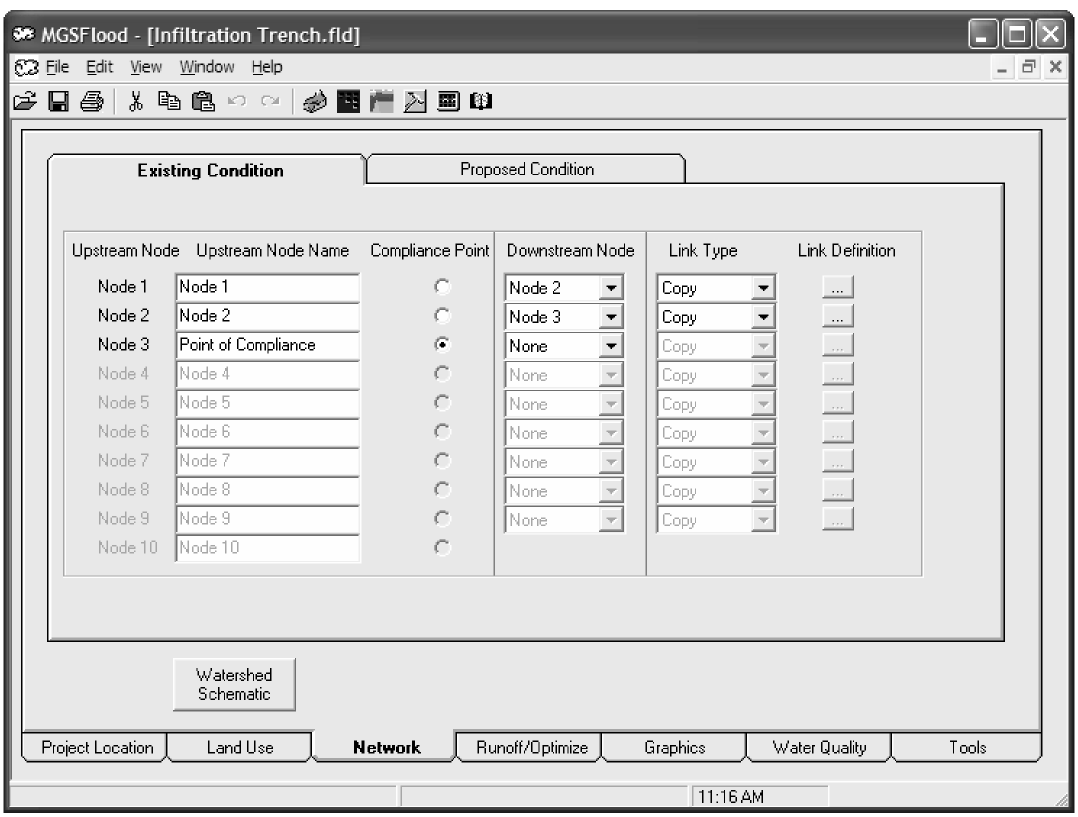
Network Tab

9. Subbasin 1 consists of the area discharging to the infiltration trench on the embankment slope. Subbasin 2 includes the area downstream of the embankment slope trench. Use the optimizer to determine the width of the lower trench.

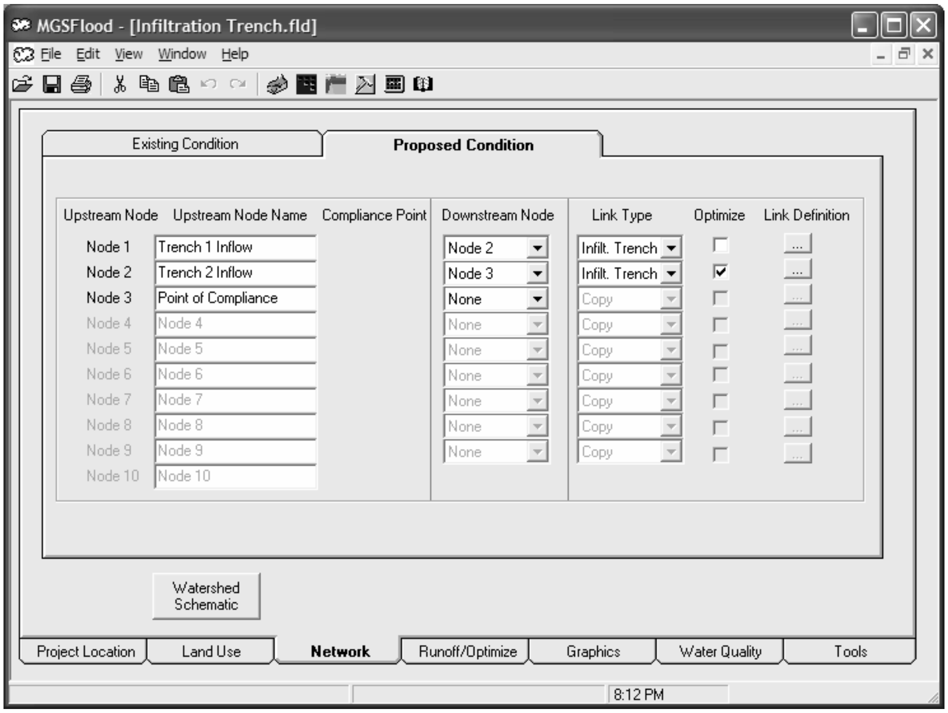
Existing **Developed**



Existing Condition Network Input



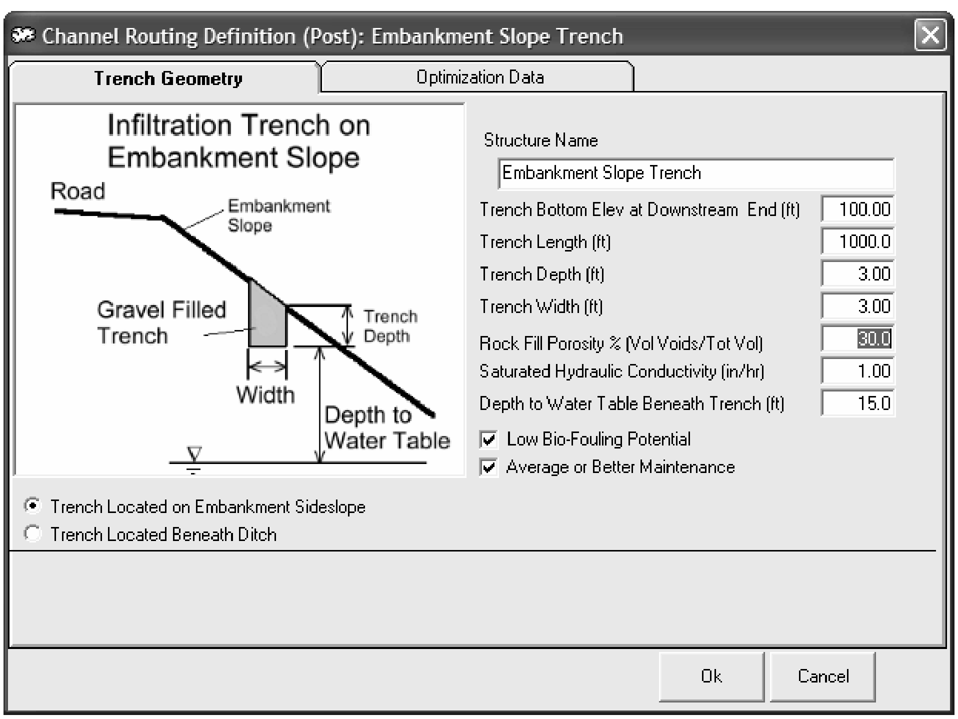
Developed Condition Network Input



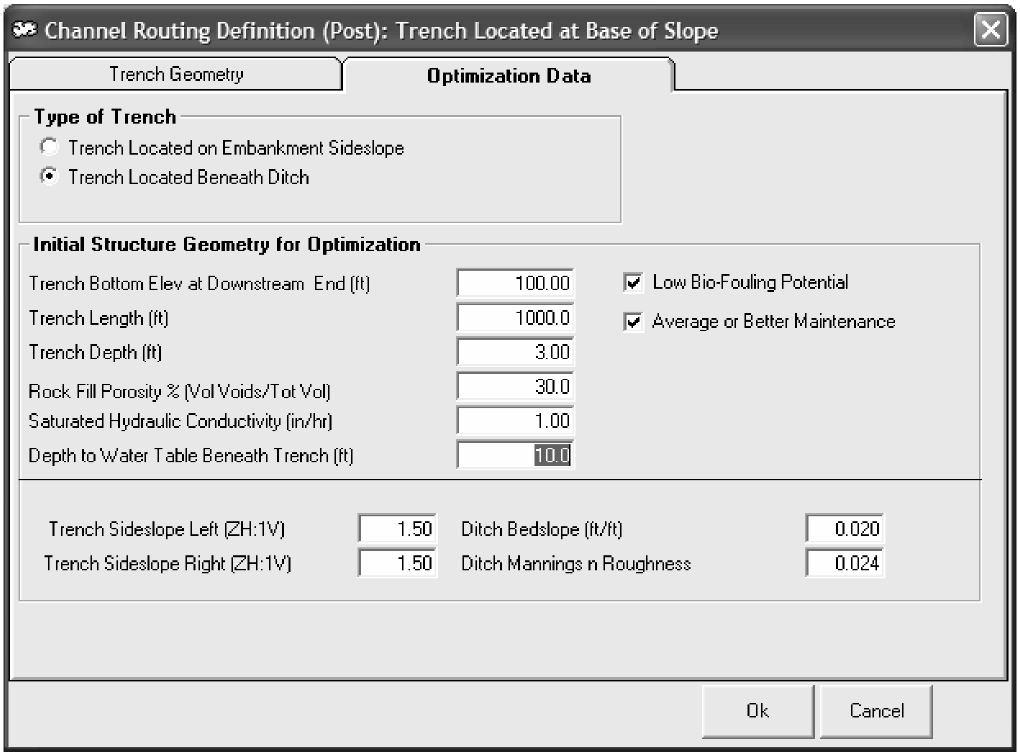
Infiltration Trench Link Input

10. Click the Link Definition for Trench 1 infiltration (the embankment slope).

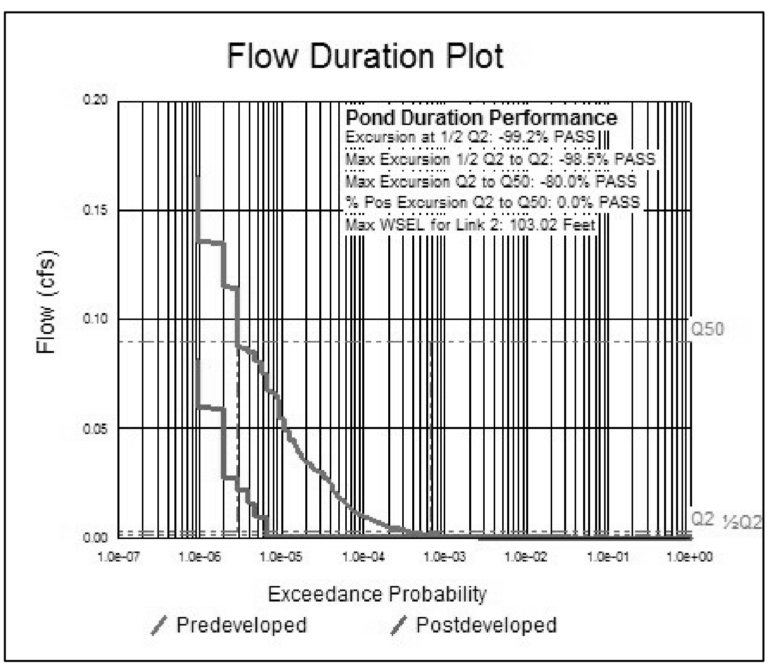
11. Enter the trench data as shown below for Trench 1 and Click OK



12. Click the Link Definition for Trench 2 infiltration (the toe of the embankment).
13. Click the Optimization Data Tab
14. Enter the trench data on the Optimization Data tab as shown below and Click OK

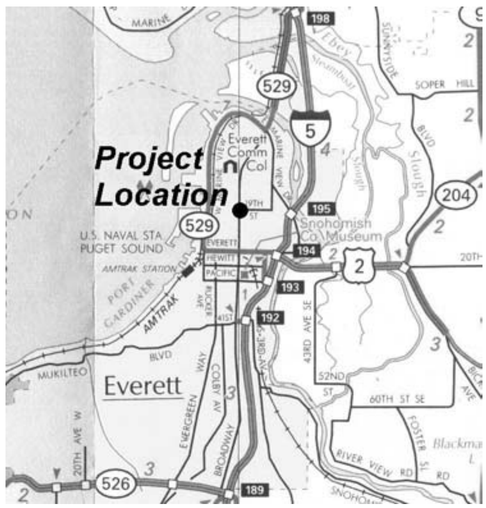


6. **Click the Runoff/Optimize tab.** Make sure the Optimize and Compute Stats for All Nodes/Links in Project are checked. Click the Route button. Review final trench size and runoff stats throughout project.



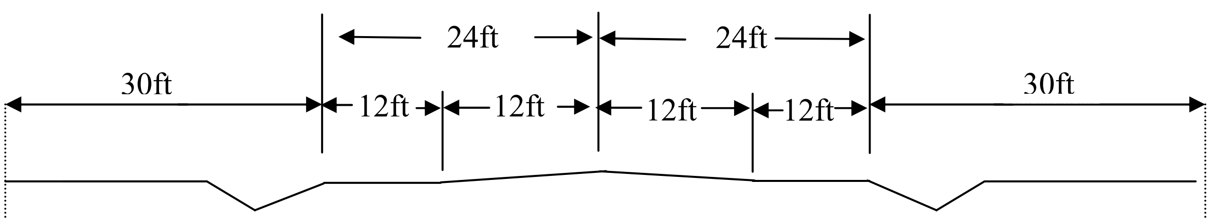
Work Session 5
Roadway Widening Problem, Detention Pond Design with Upstream Infiltration Trench

A section of highway near the city of Everett is to be improved with an additional lane in each direction.



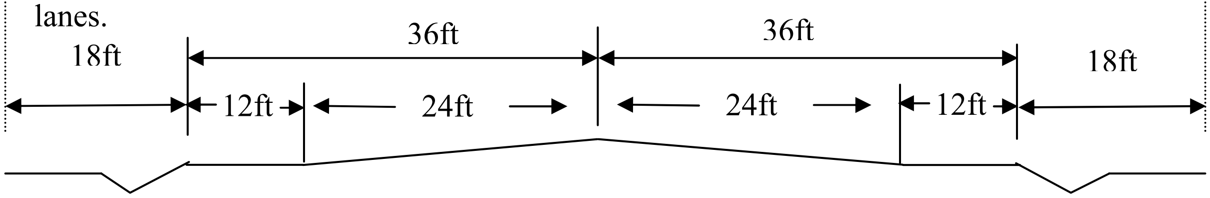
Project Location Map

The existing configuration consists of one 12-foot lane with 12-foot shoulders on each side (24-feet wide in each direction). The pervious surface is 30ft of grass which includes the ditch out to the right of way boundary.



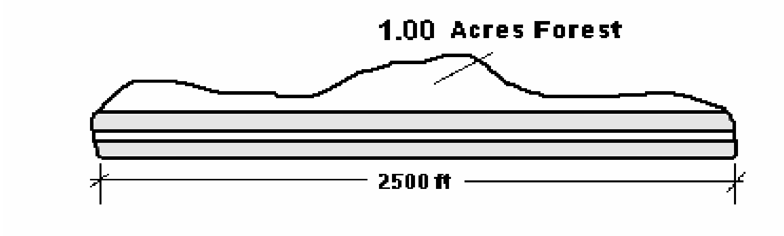
Existing Condition

The project will add one 12-foot lane in each direction, while maintaining the current shoulder widths. Both lanes will be added on the outside of the existing lanes.



Proposed Condition

Runoff from 1.0 acres of forestland upslope of the project will be intercepted by the roadway ditch and discharged to the stormwater pond. If the offsite flow was greater in area, this flow would be by-passed, refer to Chapter 4 in the 2004 HRM for design guidance.



The project is located on Alderwood soils, which are classified as SCS Hydrologic Group C.

According to the HRM, the minimum amount of mitigation is to provide flow control for the new impervious surface only. This is to avoid multiple storm sewer systems on the project.

This example will follow the Stormwater Area option method for sizing the pond, per Chapter 4 in the HRM. The pond will be designed for the mitigated area only, and then it will be checked with all the area (new and existing) draining to the pond, for flood control. The analysis of this project will have two subbasins; one for the new impervious surface (mitigation design) and one for the existing area.

Design Problem

- **I. Using this information, design a detention pond for this 2,500 foot section of roadway according to the HRM flow Stormwater Area method.**
- **II. Include an infiltration trench upstream of the pond. Redesign the pond with the infiltration trench in place. Note the reduction in pond volume. The trench dimension will be 3’ wide, 3’ deep, 500’ long. Depth to groundwater is 4’, K=1”/hour**

Analysis Steps

Start Program, Save Project File

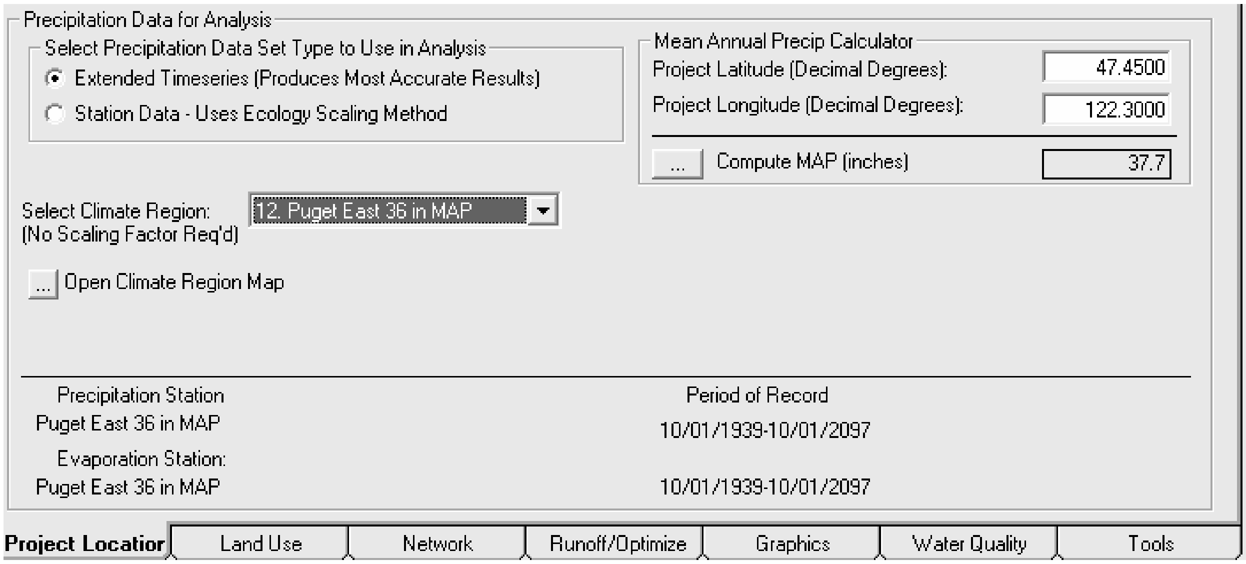
1. Start program from Windows Start button
   Start-Programs-MGS Software-MGSFlood
2. Click File Save as, Enter “Dogwood Mitigated” for Project Title. Create project folder when prompted

Project Location Tab

3. Enter project name, analysis title, and comments.
4. Check the Extended Precipitation Timeseries Option Button

5. Click the *Map* button under Climate or refer to the printed copy of the map. Locate the project on the map. Note the Timeseries Region and the mean annual precipitation for the project. Click the X on the Map window to close it. You could also use the calculator to determine the Mean Annual Precipitation for the project site.

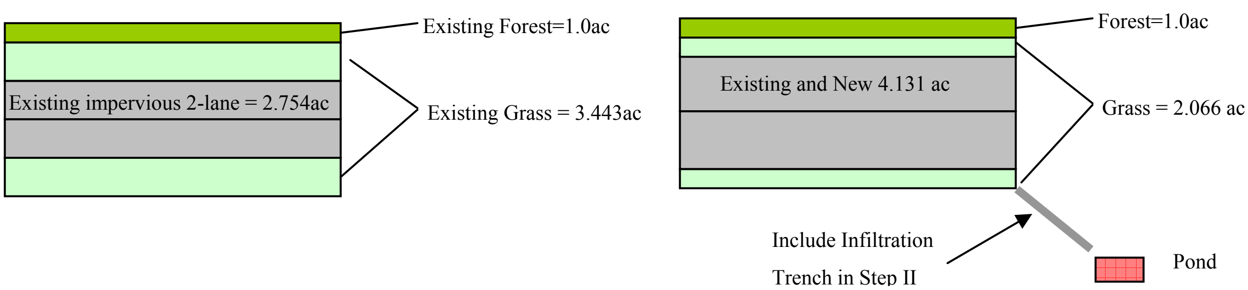
6. Select Climate Region 12. Puget East 36 in MAP from the drop down list box.



Land Use Tab

The pond will be designed for the mitigated (new impervious) area only. Subbasin 1 consists of the new impervious area and Subbasin 2 consists of the remaining area discharging to the pond.

8. Compute Pre- and postdeveloped area.



<u>Subbasin 1, New Developed Area:</u>

For SCS Type C soil, use Till

<u>Predevelopment</u>

<u>Grass:</u>
(12'+12')*2500'=60,000/43560 = 1.377 ac
Total Grass: <u>1.377 ac</u>

<u>Post-Development</u>

<u>Impervious:</u>
(12'+12')*2500'= 60,000/43560 = 1.377 ac
Total Impervious: <u>1.377 ac</u>

<u>Subbasin 1 Total: 1.377 acres</u>

Subbasin 2, All other Area Draining to Pond:
Note: Pre- and Post-Development land use are the same here, land use changes are accounted for under Subbasin 1.

Predevelopment

Forest:
Off-site Forest Run-on = 1.0 ac
Total Forest: 1.00 ac

Grass:
(18'+18')*2500' = 90,000/43560= 2.066ac
Total Grass: 2.066 ac

Impervious:
(24'+24')*2500'=120,000/43560 = 2.754 ac
Total Impervious: 2.754 ac

Post-Development

Forest:
Off-site Forest Run-on = 1.0 ac
Total Forest: 1.00 ac

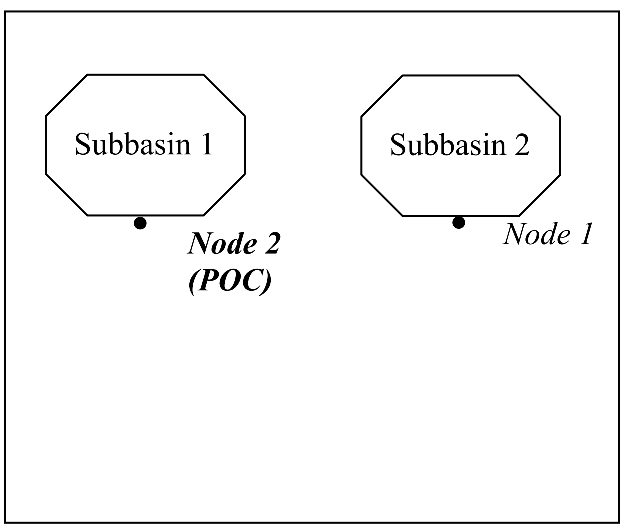
Grass:
(18'+18')*2500' = 90,000/43560= 2.066ac
Total Grass: 2.066 ac

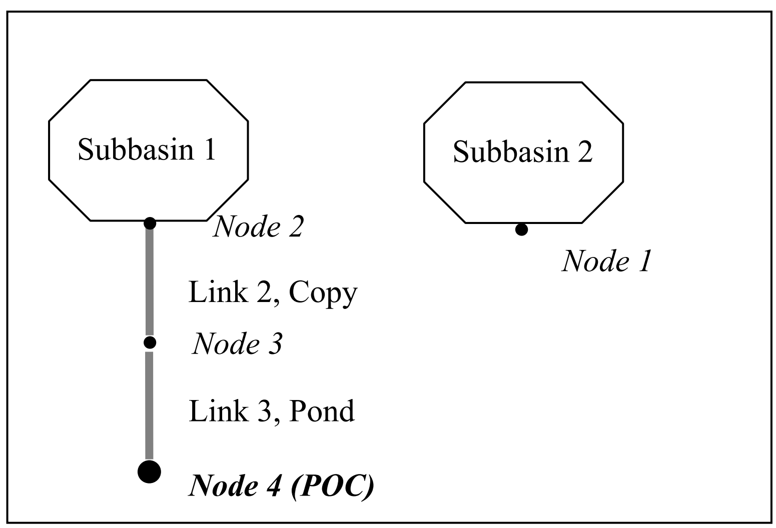
Impervious:
(24'+24')*2500'=120,000/43560 = 2.754 ac
Total Impervious: 2.754 ac

Subbasin 2 Total: 5.820 acres

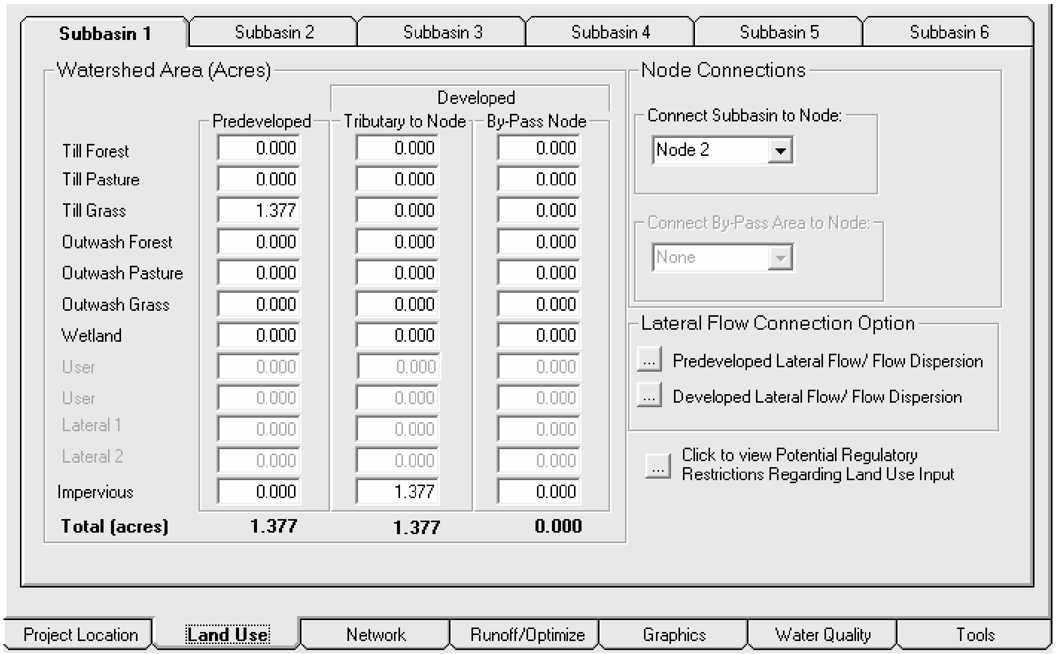
Subbasin 1+2 Total: 7.197 acres

Land Use Tab

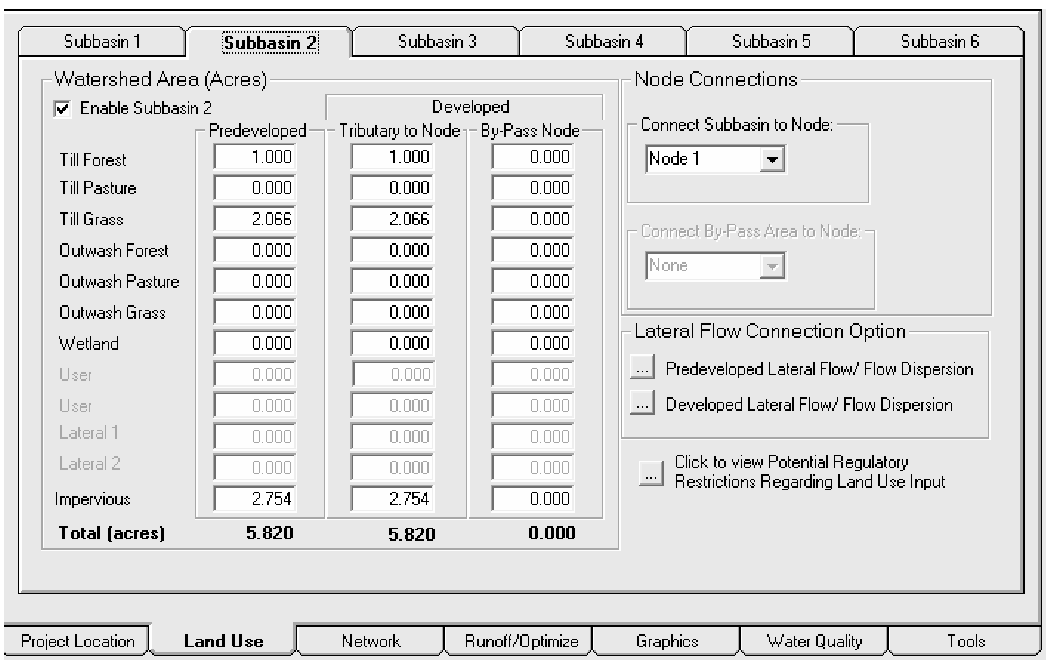




7. Enter land use from above for Subbasin 1 then Subbasin 2. Connect Subbasin 1 to **Node 2**

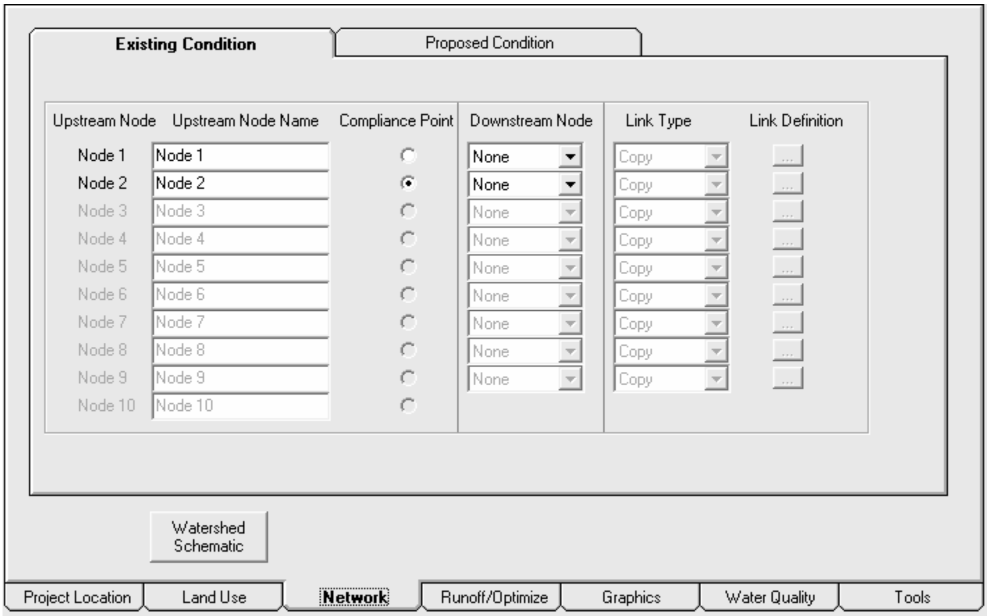


8. Connect Subbasin 2 to **Node 1**.



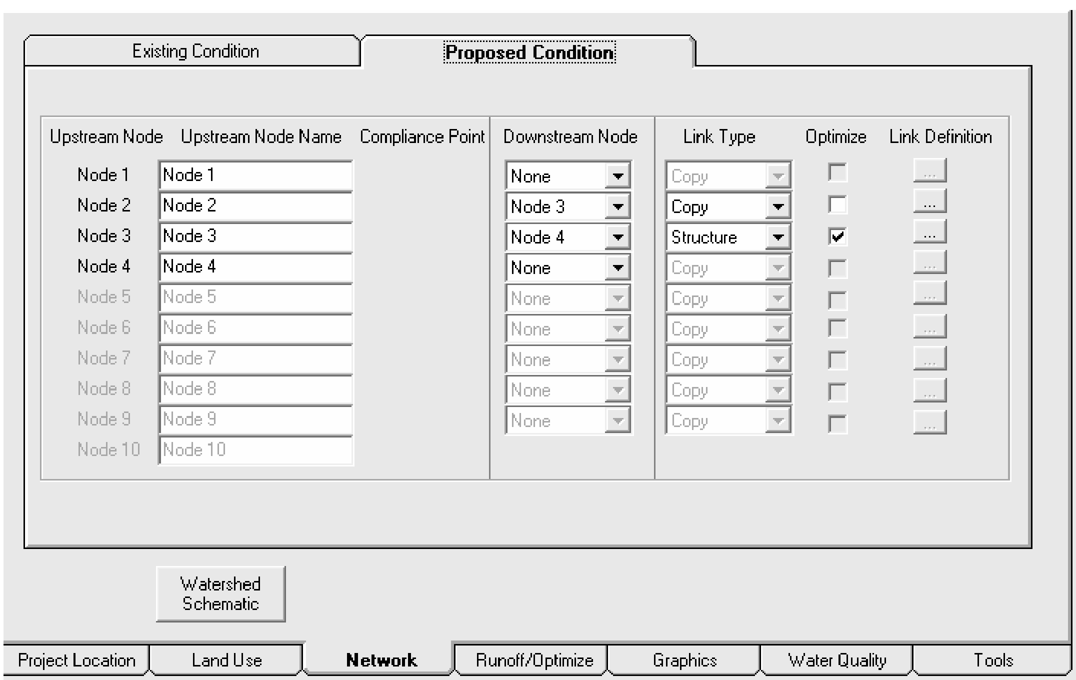
Network Tab, Existing Condition Scenario

9. According to the schematic above, no node connections are present in the Existing Condition Scenario. Node 2 is the point of compliance.



Network Tab, Proposed Condition Scenario

10. Node 1 is unconnected. Connect Node 2 to Node 3 and Node 3 to 4. Node 4 is the point of compliance. We'll connect node 1 to 2 during a later step. Check the optimize button for Link 3.

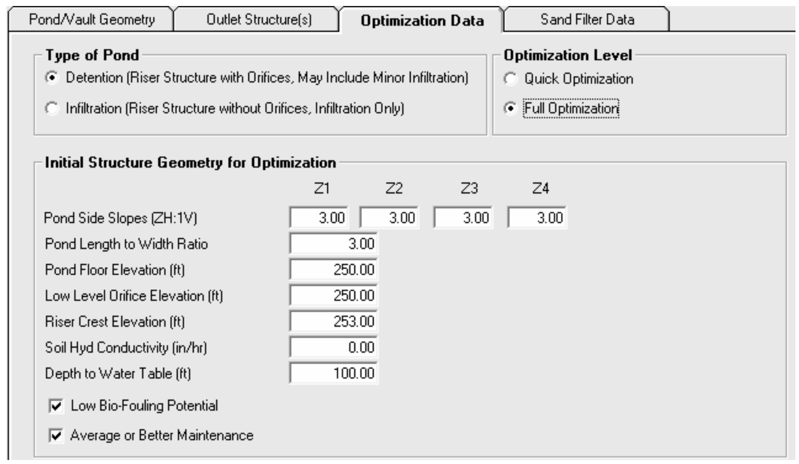


Pond Link Definition

12. Click the *Link Definition* button for the Structure Connecting Nodes 3 and 4. Click the Optimize Tab

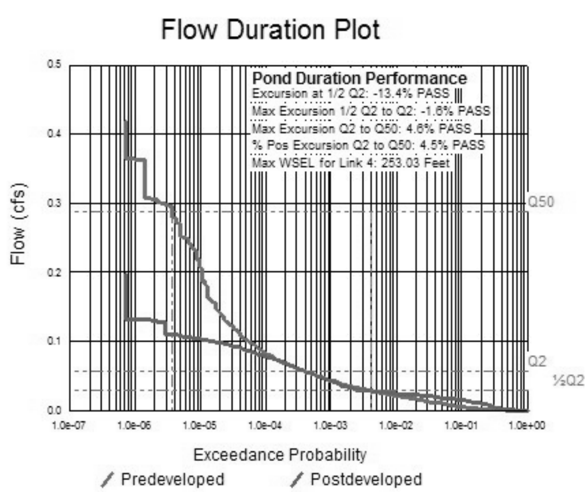
13. Enter the following general information about the pond:

a. Select *Detention* option for type of pond
b. Pond side slope of 3H:1V
c. Length to width ratio of 3.
d. Pond floor elevation of 250 ft.
e. Low Level Orifice elevation of 250 ft.
f. Riser crest elevation of 253 ft.
g. Hydraulic conductivity= 0 in/hr.
h. Make sure ***Full Optimization*** is selected.
i. Click OK to close window.



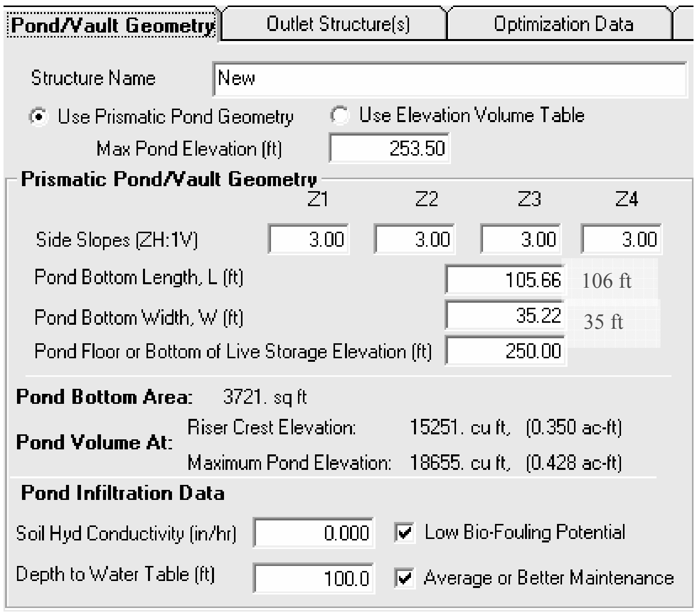
14. **Click the Runoff/Optimize tab.** Make sure the Optimize and Compute Stats for Compliance Node Only are checked. Click the Route button.

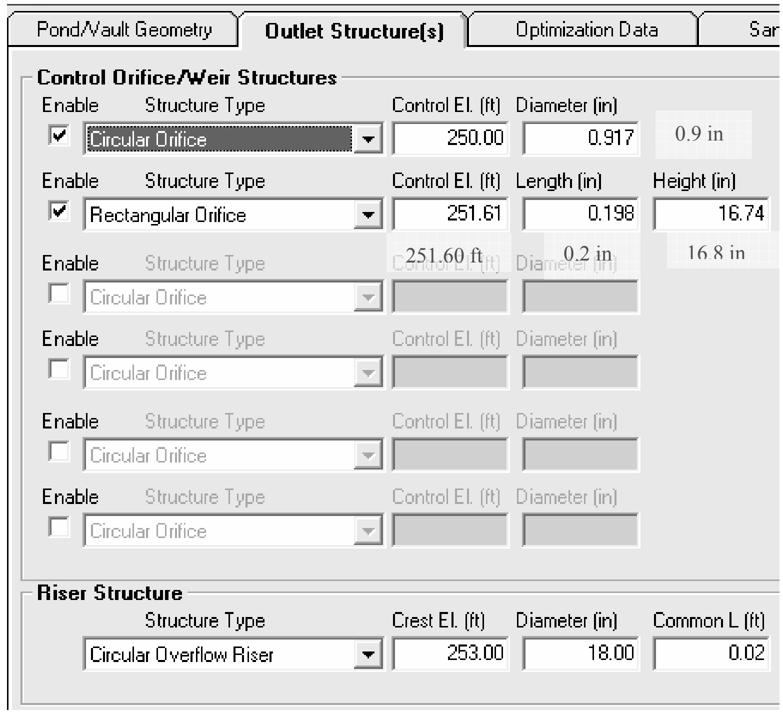
15. Check the *Flow Duration* plot to review the pond performance. The pond must pass all 4 Ecology criteria for it to be an acceptable design.



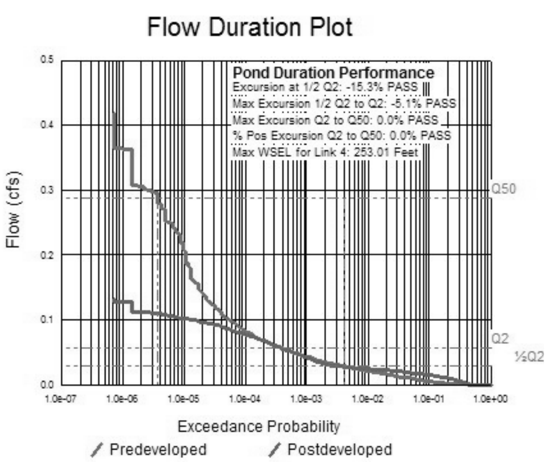
Since the design meets duration and frequency requirements, the next step is to check the actual dimensions the program used and adjust as necessary.

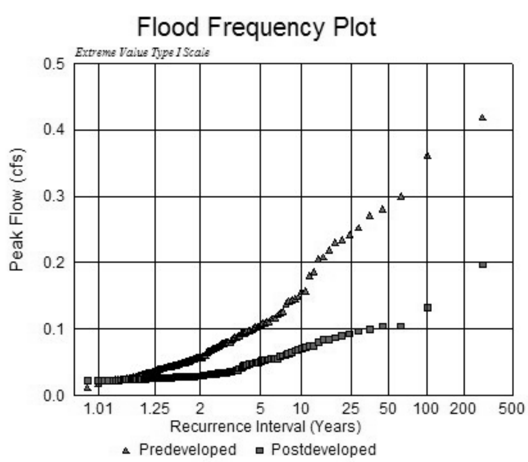
16. Click the *Network* tab, reopen the Link Definition for the Pond.
The resulting pond geometry and outlets are displayed on the Pond Vault Geometry and Outlet Structure tabs. Make the dimension constructible and nominal in size as shown. Click OK to close the window.





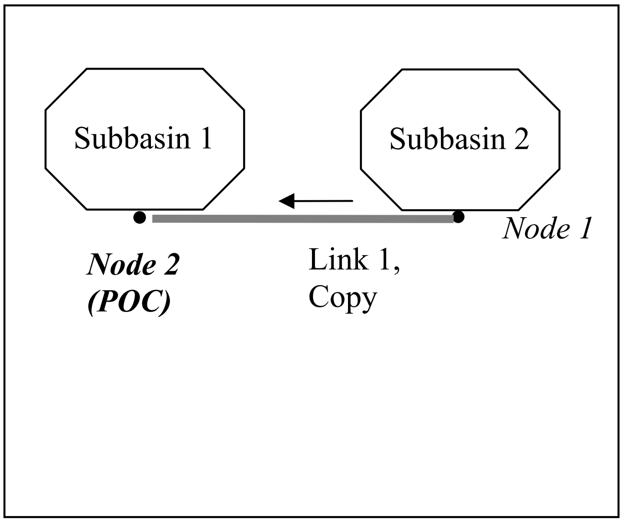
17. **Click the Runoff/Optimize tab.** Make sure the Optimize box is <u>unchecked</u>. Click Route Button. As seen below, both the duration and frequency plots are in compliance. The first step has been completed. The next step is to route runoff from the new and existing areas tributary to the pond and check that the 100-year peak discharge has not increased.

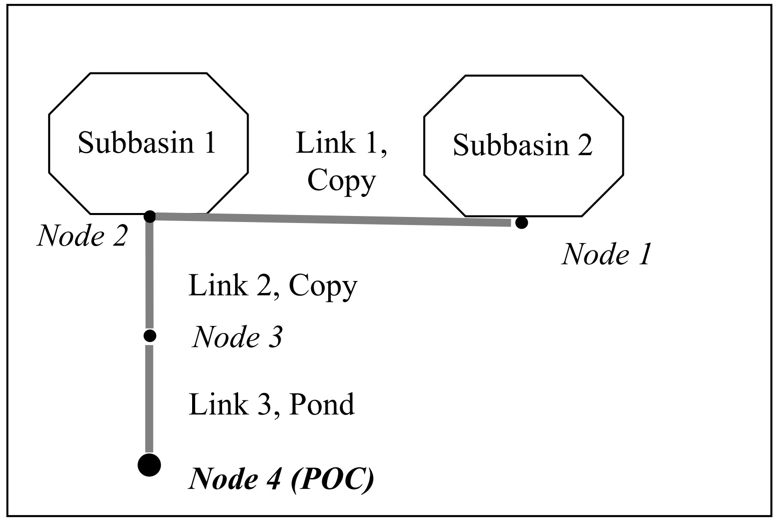


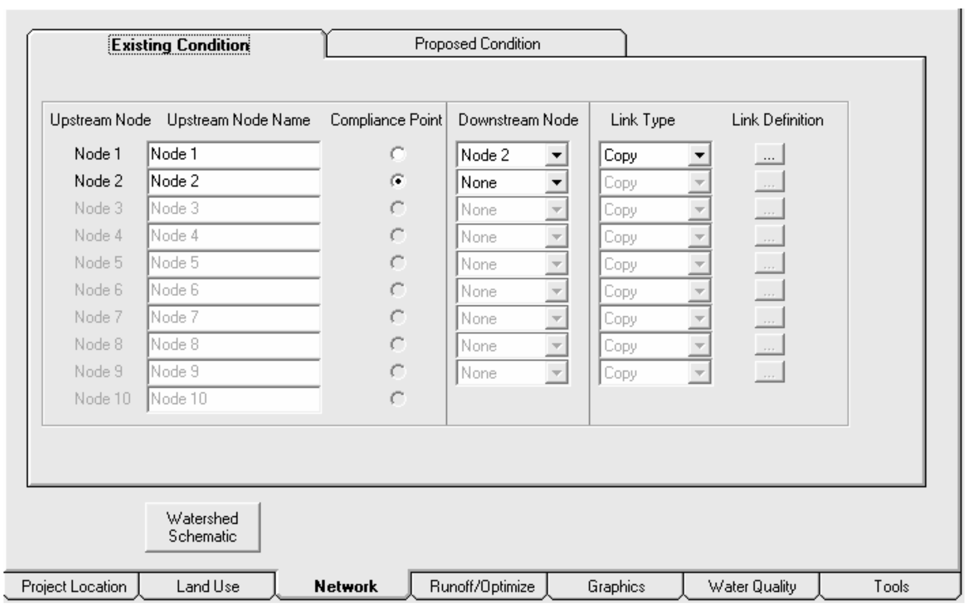


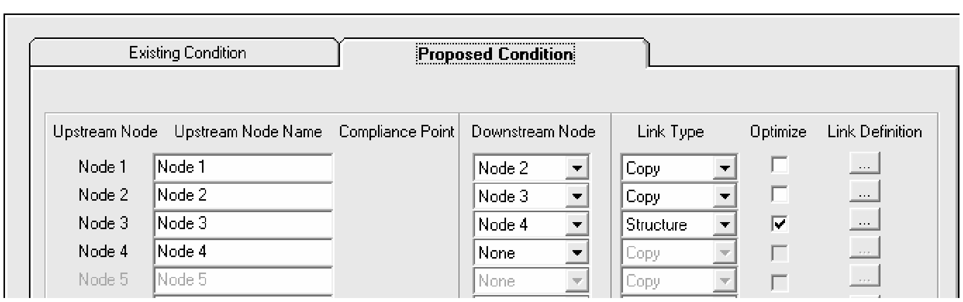
Check the Non-mitigated flows
Using the same input file, go back to the *Network* tab and change the node connections.

Connect Node 1 to Node 2 for both the existing and Proposed Condition Scenarios. This will combine runoff from Subbasins 1 and 2 before entering the pond.





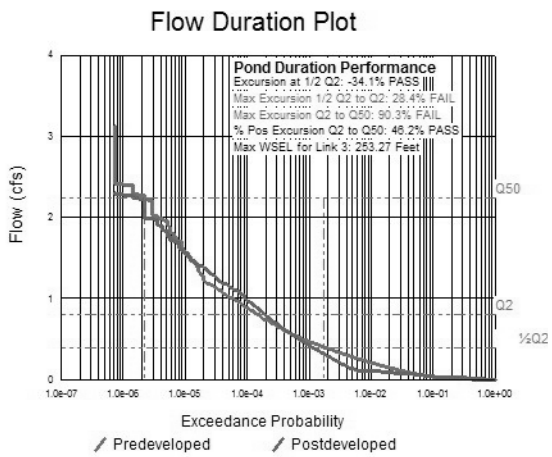


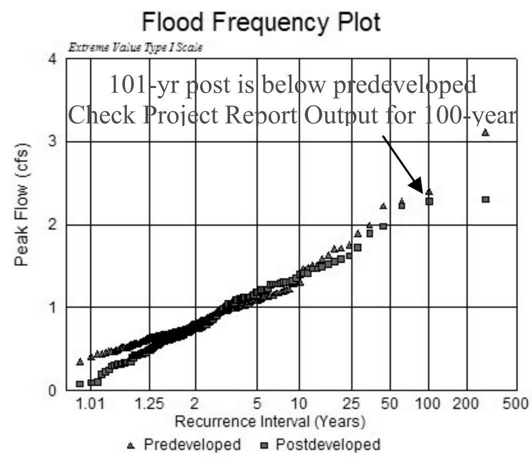


Runoff/Optimize tab

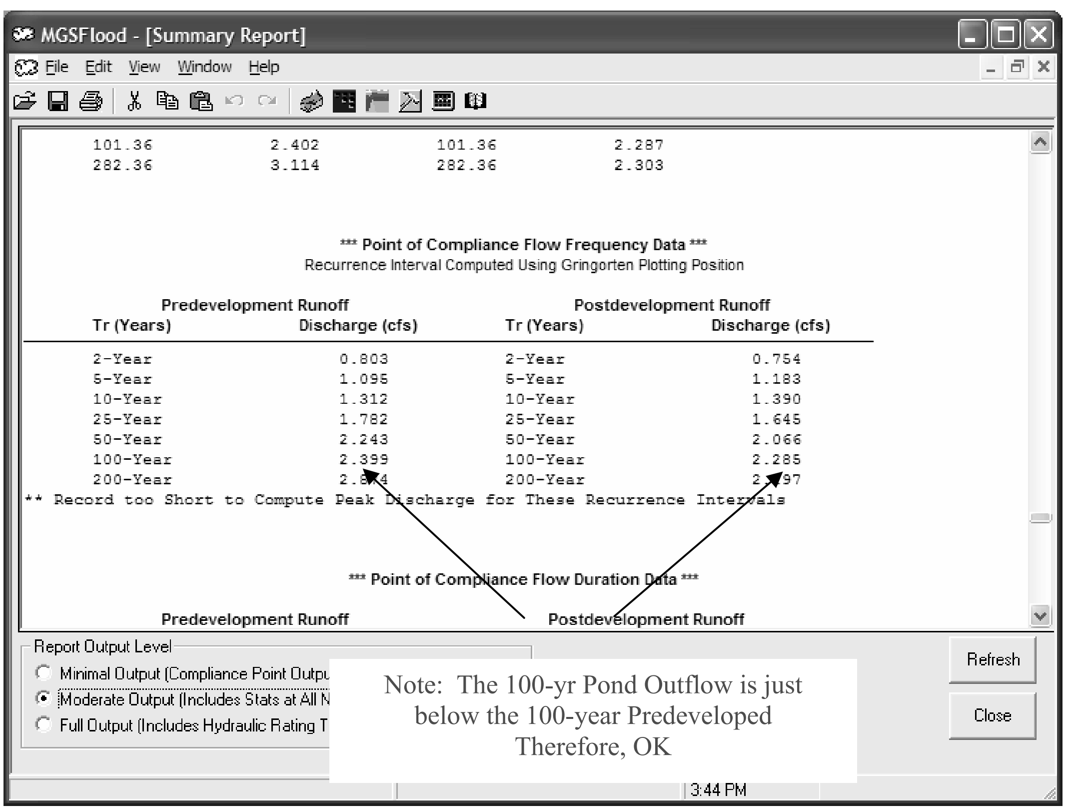
18. Make sure the Optimize Structure box us unchecked. Click the Route button.

As seen below, the duration performance is not in conformance, which is expected since we're routing a larger area to the pond. In the frequency plot, we want to make sure the 100-year developed peak discharge is less than the predeveloped, which it is.





Click the report button on the top of the screen to view the project report. Scroll down about ¾ of the way through the report. Note the 100-year pond discharge compared to the 100-year predeveloped discharge.



Note: If the 100-year pond discharge were greater than the predeveloped 100-year, then the pond volume would have to be increased to reduce the discharge below predeveloped levels. This may not be possible without drastically increasing the size of the pond because the pond discharge often represents a small fraction of the total 100-year discharge from the site when using the Stormwater Area Method.

In this example, the pond discharge at overflow is 0.113 cfs compared to the 2.28 cfs for the 100-year total from the site

Check Overflow Riser Capacity

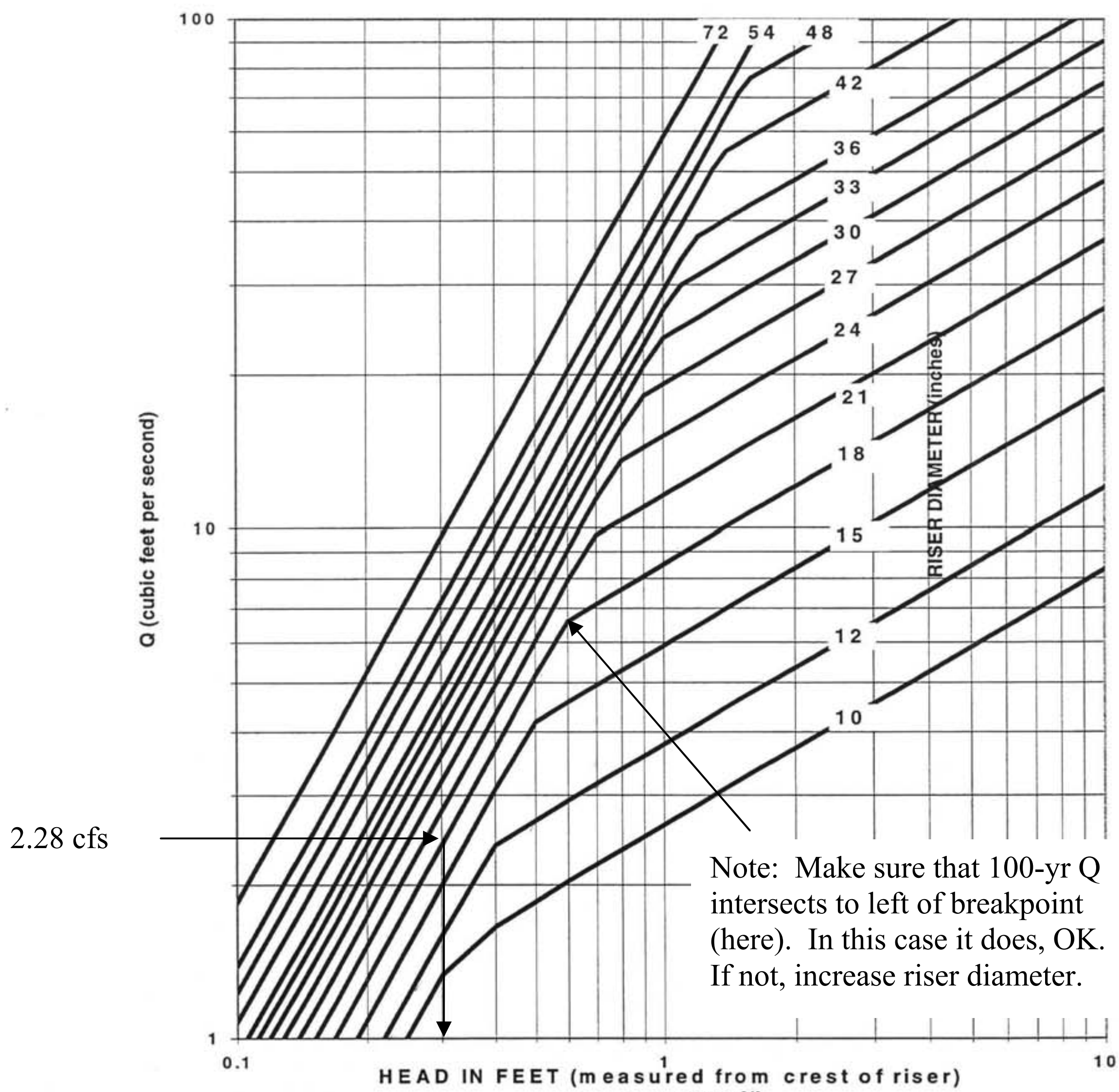
The MGS Flood Optimizer sizes the overflow riser diameter based on the runoff from the tributary area to the pond. For the Stormwater Area Method, this is accomplished in the first step when just the mitigation area is connected to the pond. Since a much larger area will be connected to the pond (mitigated and unmitigated areas), we have to check the capacity of the overflow riser.

Use the 100-year pond discharge rate computed using the full tributary area to the pond.
Q(100)=2.28 cfs., Riser Diameter=18 inches.
Use the Riser Overflow nomograph to make sure that the riser has sufficient capacity to pass the design discharge while maintaining weir flow at the crest.

Riser Overflow

The nomograph in Figure 5.3.4.H can be used to determine the head (in feet) above a riser of given diameter and for a given flow (usually the 100-year peak flow for developed conditions).

FIGURE 5.3.4.H RISER INFLOW CURVES



$Q_{weir} = 9.739\ DH^{3/2}$

$Q_{orifice} = 3.782\ D^2 H^{1/2}$

Q in cfs, D and H in feet

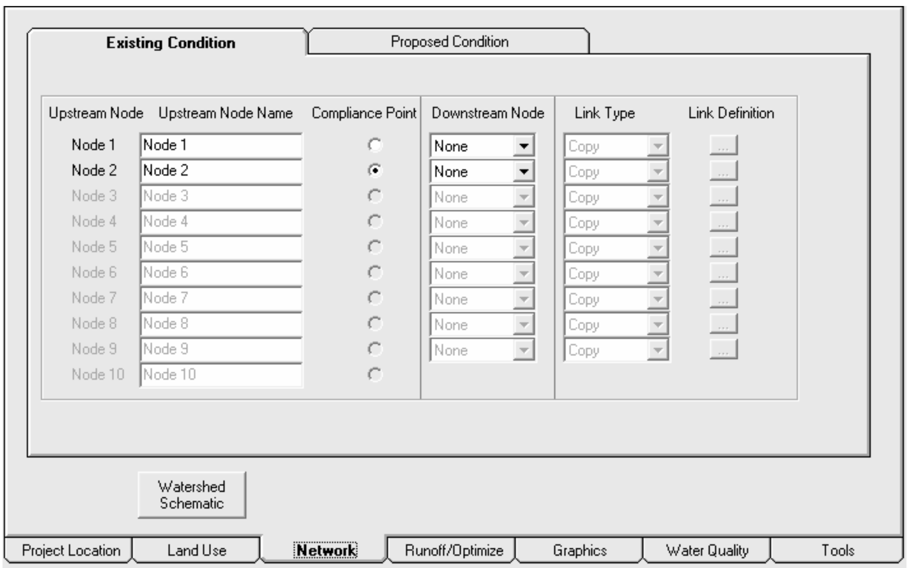
Slope change occurs at weir-orifice transition

- **II. Include an infiltration trench upstream of the pond. Redesign the pond with the infiltration trench in place. Note the reduction in pond volume compared to the current condition without the trench. The trench dimension will be 3’ wide, 3’ deep, and 500’ long. Depth to groundwater is 4’, K=1in/hr, rock fill porosity=50%, trench Side Slopes 2H:1V, trench Slope 0.02, and Manning’s Roughness 0.24**

We’ll use the optimizer to redesign the pond with the infiltration trench upstream. To do this, we need to disconnect Subbasin 2 so that only the new runoff will be considered in the design.

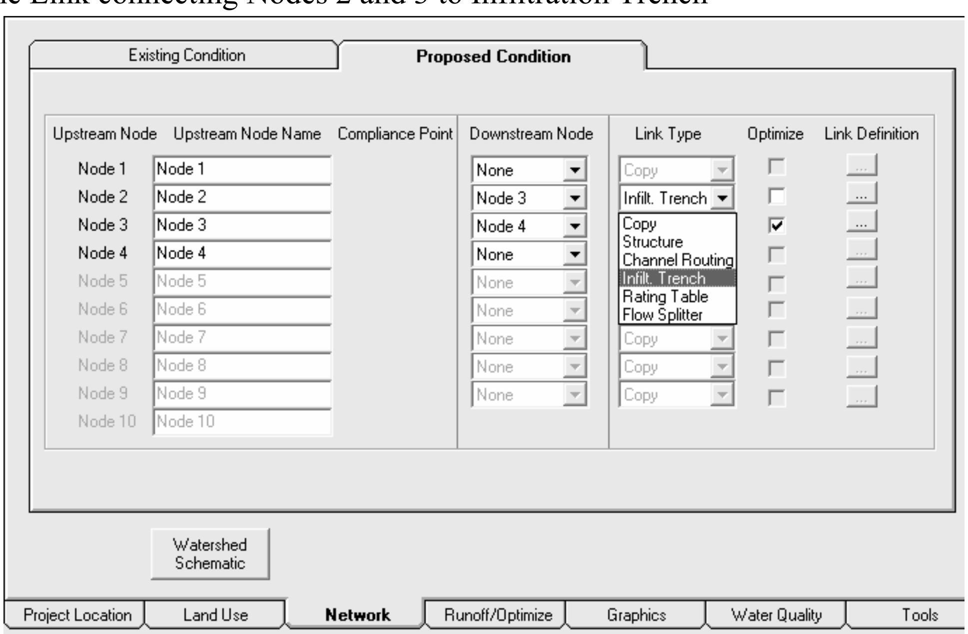
Network Tab, Existing Condition Scenario

19. Disconnect Subbasin 2 by disconnecting Node 1 (Set to None)



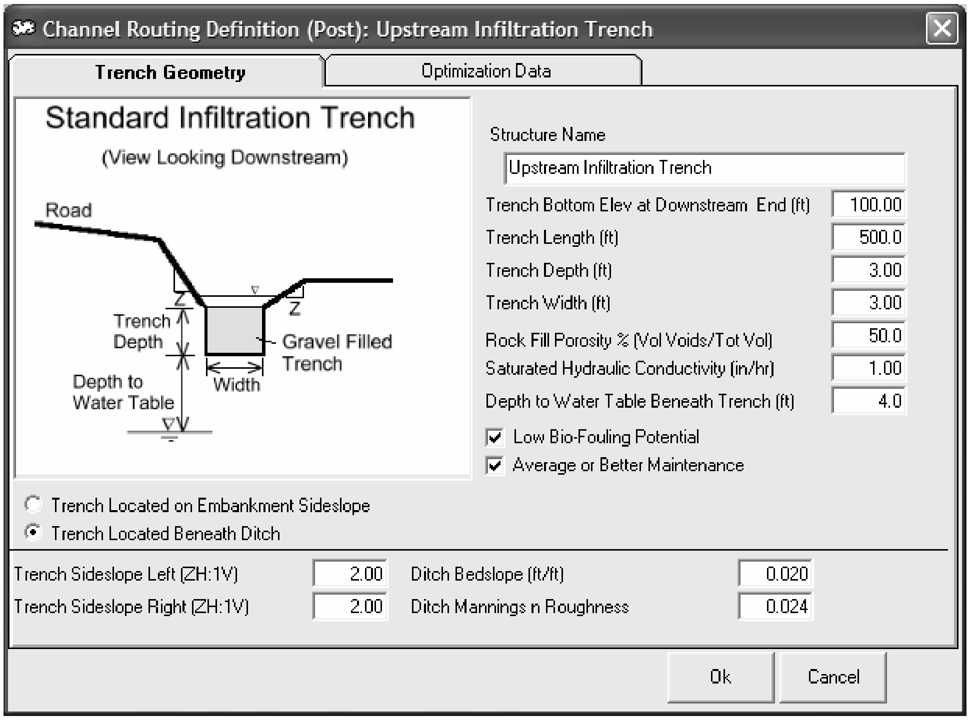
Network Tab, Proposed Condition Scenario

20. Similarly, set the downstream Node Connection to None for Node 1 and set the Link Type for the Link connecting Nodes 2 and 3 to Infiltration Trench



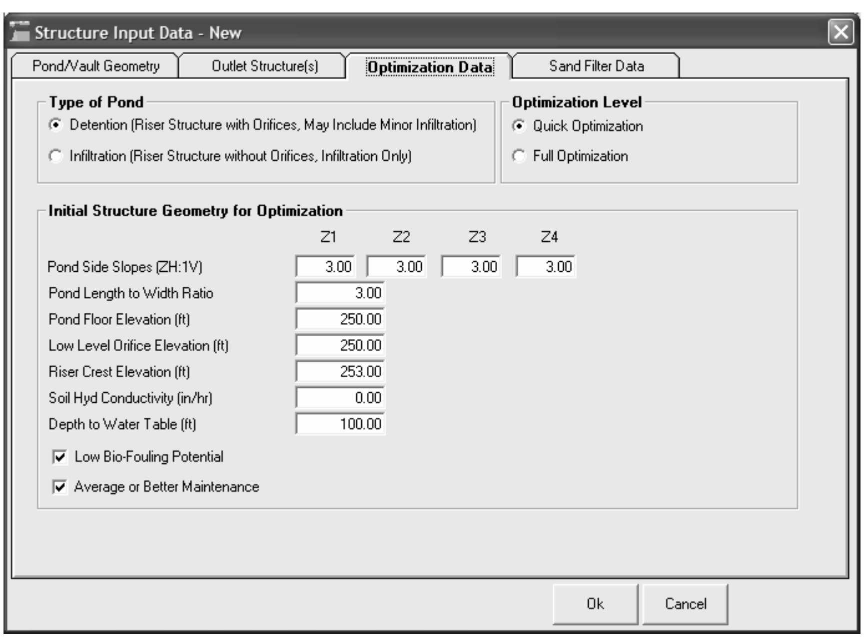
Infiltration Trench Link Definition

Click the *Link Definition* button for the Structure Connecting Nodes 2 and 3. Enter the following information and Click OK



Infiltration Trench Link Definition

Click the *Link Definition* button for the Pond (Structure Connecting Nodes 3 and 4). Click the Optimization Tab. Make sure that the <u>Quick</u> Optimization Option is selected as shown below then Click OK



Runoff/Optimize tab

21. Make sure the Optimize Structure box us unchecked. Click the Route button.

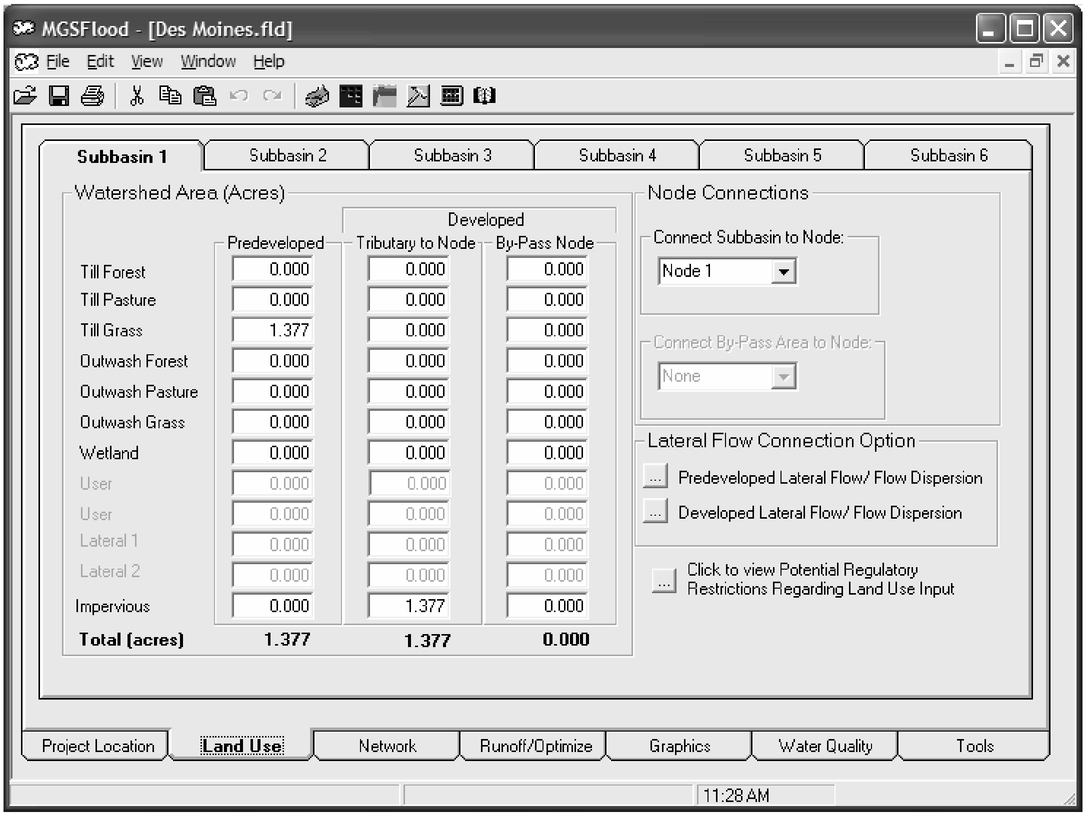
Compare the pond volume obtained with and without the infiltration trench upstream.

Volume without Upstream Trench at Riser Crest Elevation: 0.357 ac-ft
Volume with Upstream Trench at Riser Crest Elevation: 0.238 ac-ft

Work Session 6 – Water Quality Design Examples

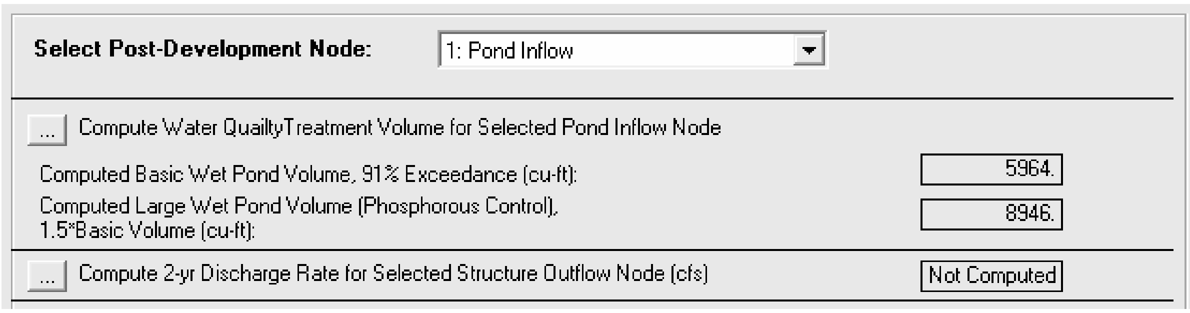
Determine a "Large" wet pond volume required for the DES MOINES roadway widening example. Determine the depth of water quality dead storage required

1. Open the Des Moines input file. Use the File Open commands from the menu.
2. Click the Land Use Tab
3. Make sure that the land use corresponds to that shown below.

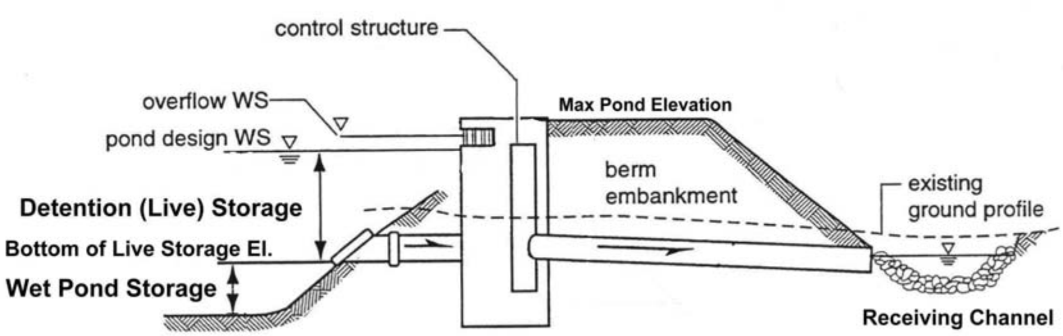


4. Click the Route button from the Runoff/Optimize tab. Make sure that the Optimize Structure Indicated on Network tab is not checked.

5. Click the *Water Quality* tab. The basic wet pond volume is calculated using the pond inflow node. Select the pond inflow node from the drop down list box. Click the Compute Water Quality Treatment Volume button. The results will be displayed on the form. The "Large" wet pond volume is also provided, which is the basic volume multiplied by 1.5.



6. Compute Depth of Wet Pond Storage



Dead Storage Volume: $V = D\left(\frac{A_t + A_b + \sqrt{A_t A_b}}{3}\right)$

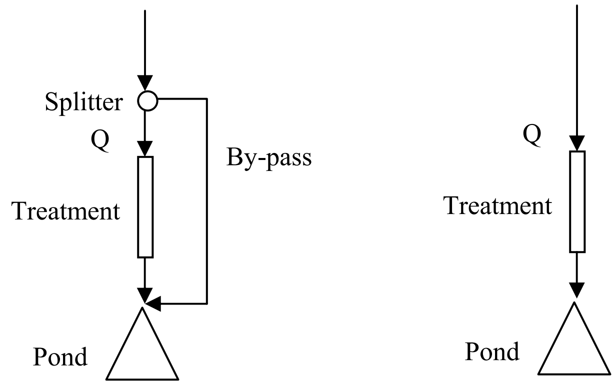
D= Storage Depth (Unknown)
V= Water Quality Volume (8946 cu-ft)
A_t= Top of Wet Pond Storage Area (3916 sf)
A_b= Bottom of Wet Pond Storage Area Computed by:

A_b= (L-2ZD)(W-2ZD)

L= Length of Pond at Top of Wet Pond Storage (89 ft)
W= Width of Pond at Top of Wet Pond Storage (44 ft)
Z=Pond Side slopes (3)

By trial, A_b= 1675 , D=3.3 ft (minimum)

Determine the "on-line" and "off-line" design discharge rate for the pond inflow node.



Upstream of Detention Facility, Off-Line **Upstream of Detention Facility, On-Line**

1. Click the *Water Quality Data* tab.
2. Select the node representing the inflow to the pond from the drop down list.
3. Click the *Compute Water Quality 15-minute Design Discharge* button. On-line and off-line discharge rates will be reported on the tab and in the project report.

Determine the geometry of the "off-line" Flow Splitter Structure that will fit in a 48" diameter manhole.

When an *off-line* treatment approach is used, a flow-splitter is needed for bypassing flows that exceed the design flow rate. The splitter structure includes an orifice and on overflow weir (Figure 12.14), and the design guidelines are listed below.

- The maximum head on the overflow weir must be minimized for flow in excess of the water quality design flow. Specifically, flow to the water quality facility at the 100-year water surface must not increase the design water quality flow by more than 10-percent.

- The splitter structure requires an orifice plate upstream of the discharge pipe that leads to the water quality treatment facility. The design water surface should be set to provide a minimum headwater/diameter ratio of 2.0.

The splitter design is a trial and error procedure whereby the orifice diameter is selected by the user. The program then computes the height of the baffle wall, the length of the overflow weir, and the ratio of the baffle wall height to orifice diameter. There is not a unique solution and the user should select an orifice size that produces a baffle wall height and overflow length that will conveniently fit in a standard manhole (or other structure) and meets the required headwater/diameter ratio of 2.0.

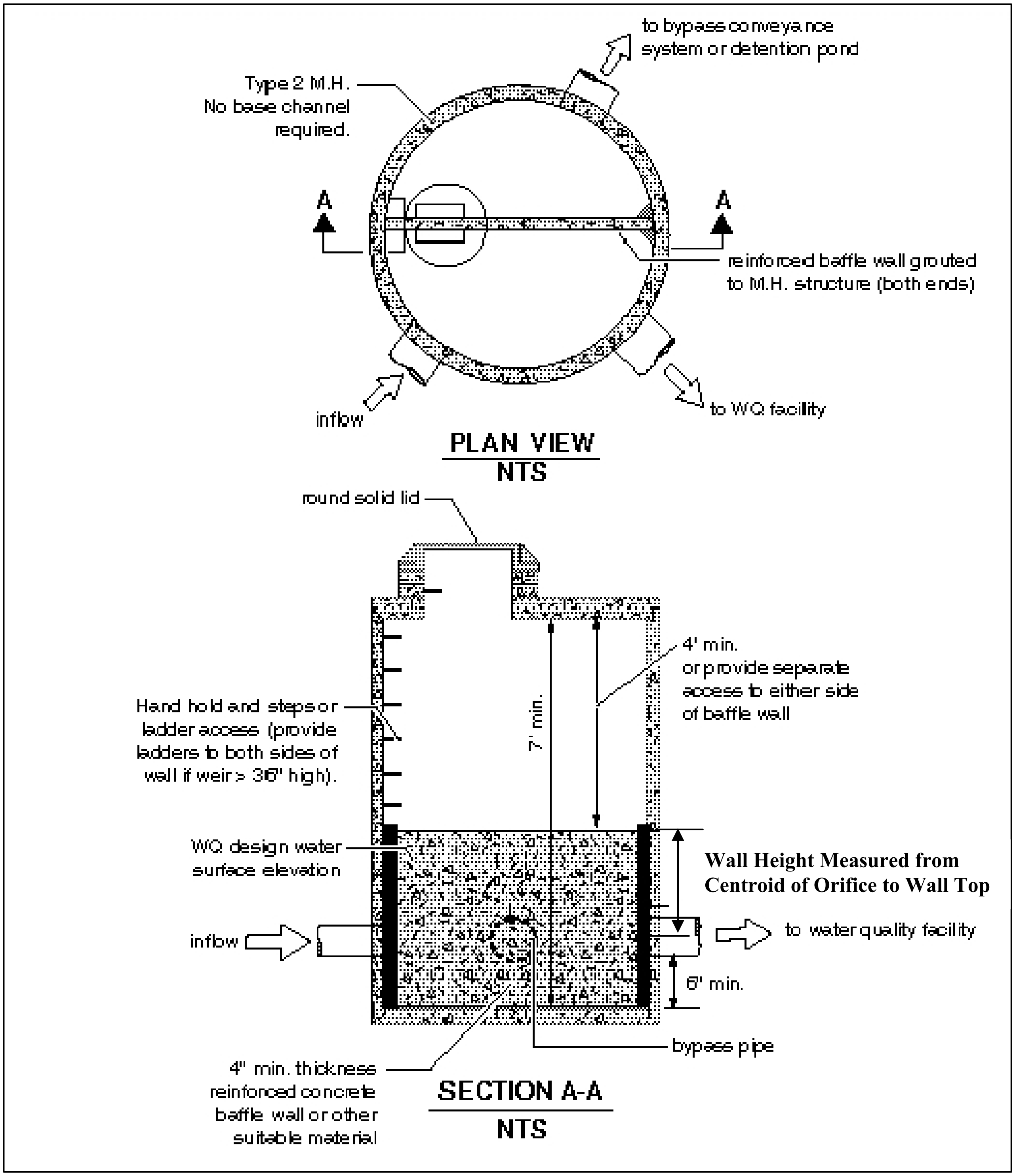
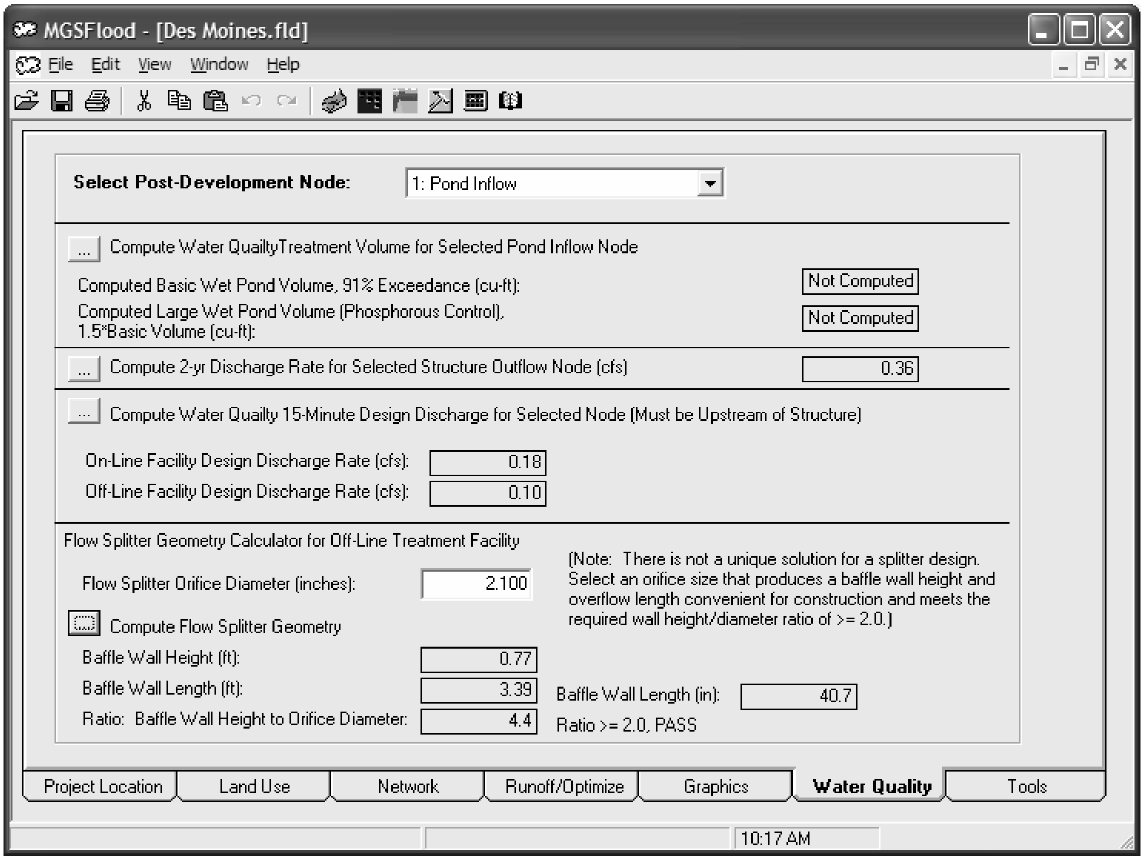


Figure 12.14 – Flow Splitter Geometry (per Ecology Stormwater Management Manual)

1. Enter an orifice size of 6”, Click the Compute Flow Splitter Geometry button
2. Try an orifice size of 4”.
3. Repeat the process until the weir length just fits in the manhole (48”) and the ratio criteria are met.



Work Session 7 – Using MGSFlood to Design a Pipe Vault

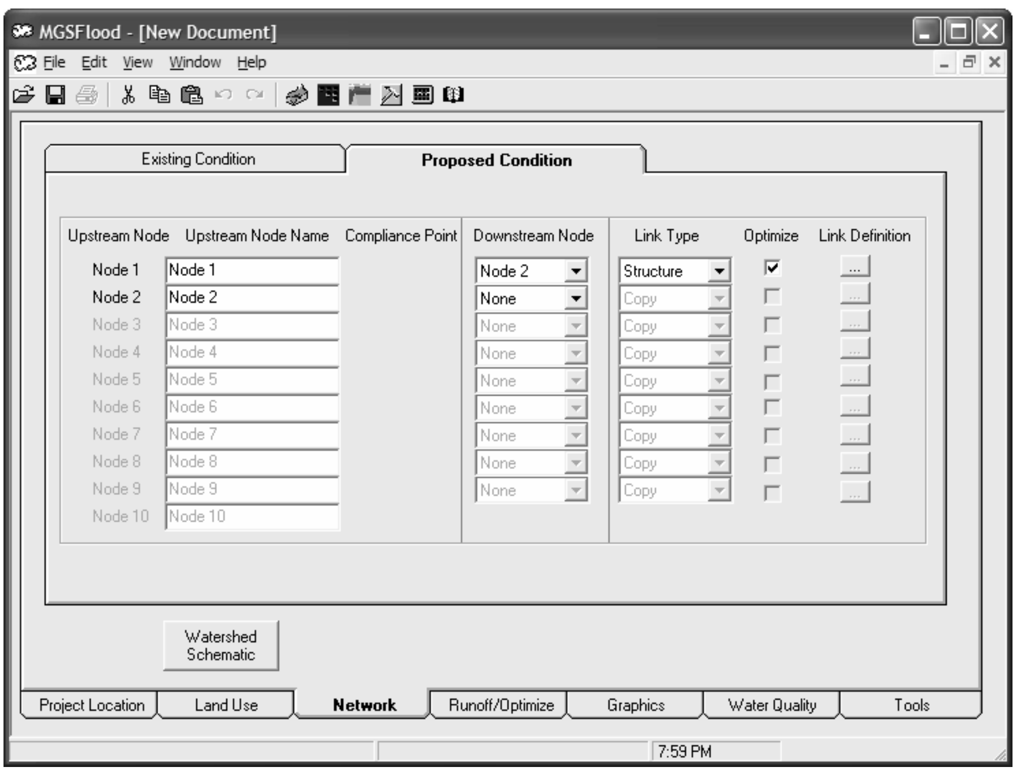
Pipe vaults consist of concrete or corrugated metal pipes buried horizontally and equipped with control structures at the outlet. A spreadsheet has been developed to aid in the design of pipe vaults using MGSFlood. The procedure is outlined below.

1. Use MGSFlood with the optimizer to size a hypothetical pond for the project.
2. Enter the outlet works obtained from the optimizer on the spreadsheet PondHydraulics.xls and size the pipe to develop a vault with volume/discharge characteristics similar to that obtained from the optimizer.
3. Copy the rating table from the spreadsheet to MGSFlood and route flows to determine the performance.

Example

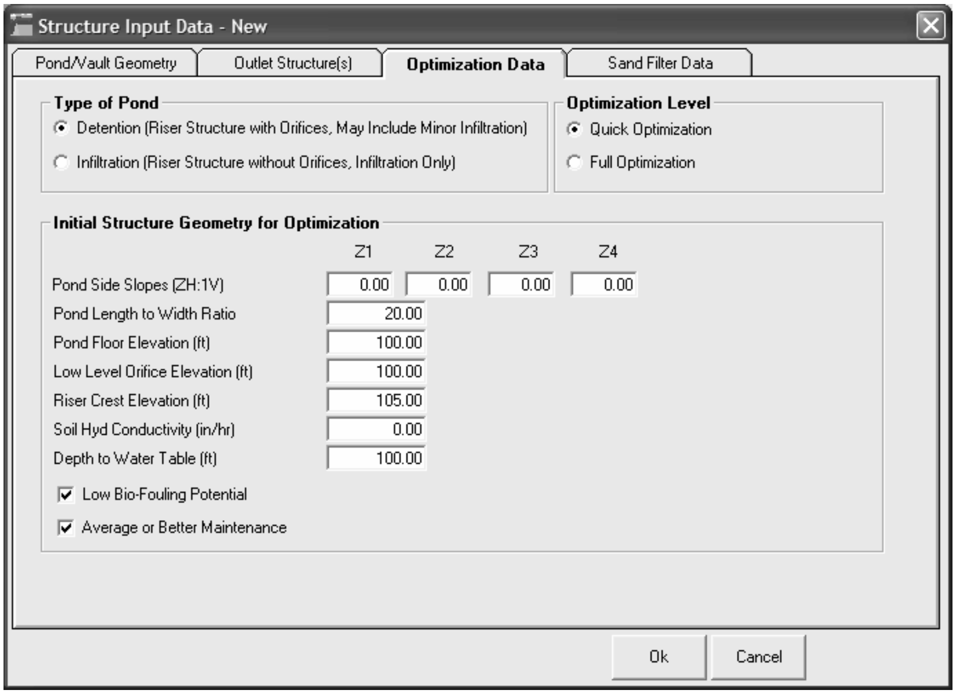
A road project will convert 2 acres of till grass to impervious. Due to right-of-way limitations, the project proponent whishes to use a buried horizontal pipe to detain the runoff. Use MGSFlood and PondHydraulics.xls to design a pipe vault for the project. Assume a 60" diameter pipe and used Extended Precipitation Timeseries 13, Puget E 40" MAP.

1. Start MGSFlood, save the project, and enter the land use on the Land Use tab.
2. On the network tab, define a structure connecting Node 1 and Node2.



3. Open the link definition and select Optimize

4. Enter the following information on the Optimizer page and Click OK.



5. Click the Runoff/Optimize Tab. Check the Optimization button and click Route.
6. Open the Link definition for the pond returned from the optimizer.
7. Open PondPipe.xls. Enter the pond volume at the riser crest elevation obtained from the optimizer. Enter the pipe diameter and length so that the pipe volume approximates the volume obtained from the optimizer.

Detention Pipe Volume Calculator

Blue Indicates Data Entry Cells, the rest are calculated.

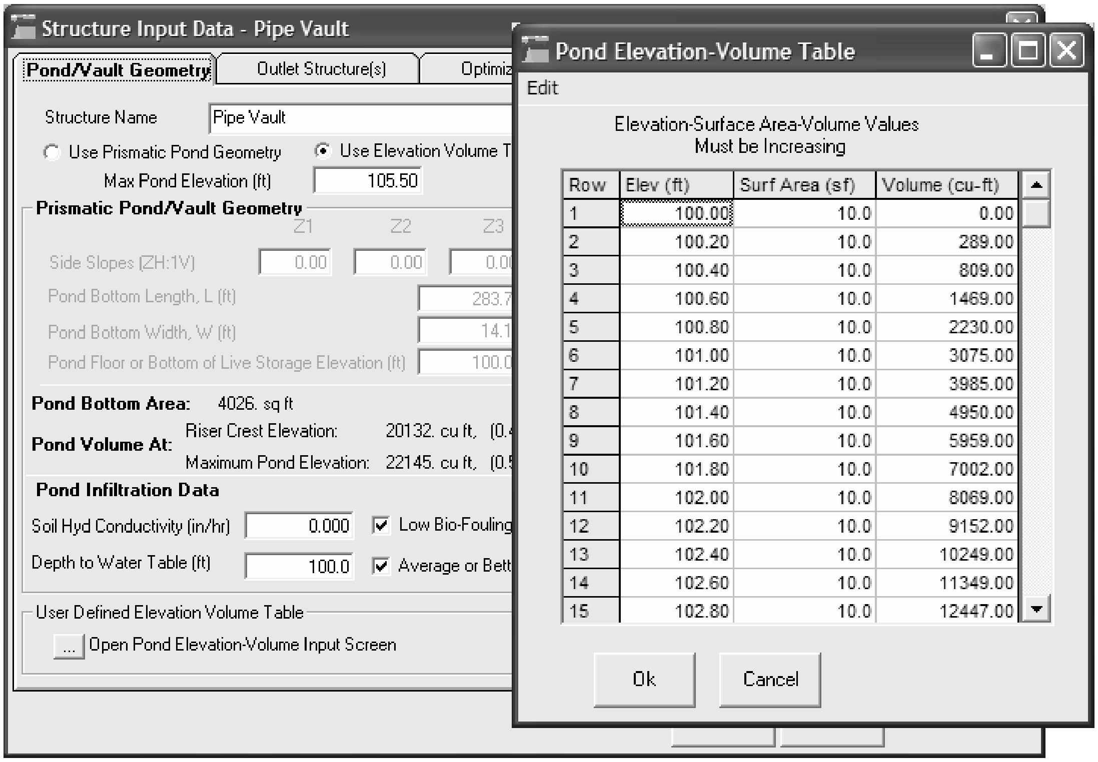
MGS Software LLC

Storage Volume Provided by Horizontal Pipe of Diameter d

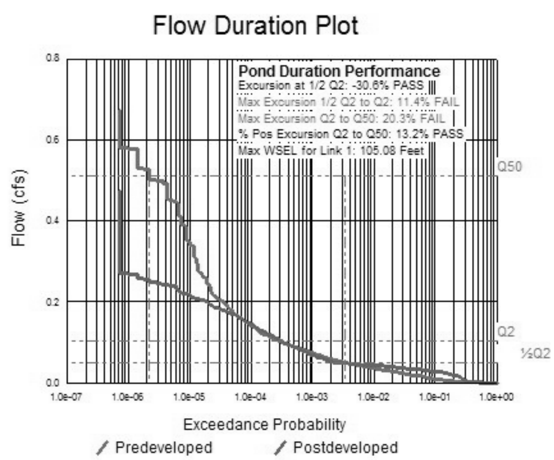
Pipe Diameter (d)	**5.0**	**ft**
Pipe Length	**1,100**	**ft**
Overflow Elevation:	**105.00**	**ft**

Pond Volume at Overflow (cu ft):	21599
Target Volume from MGSFlood:	20132

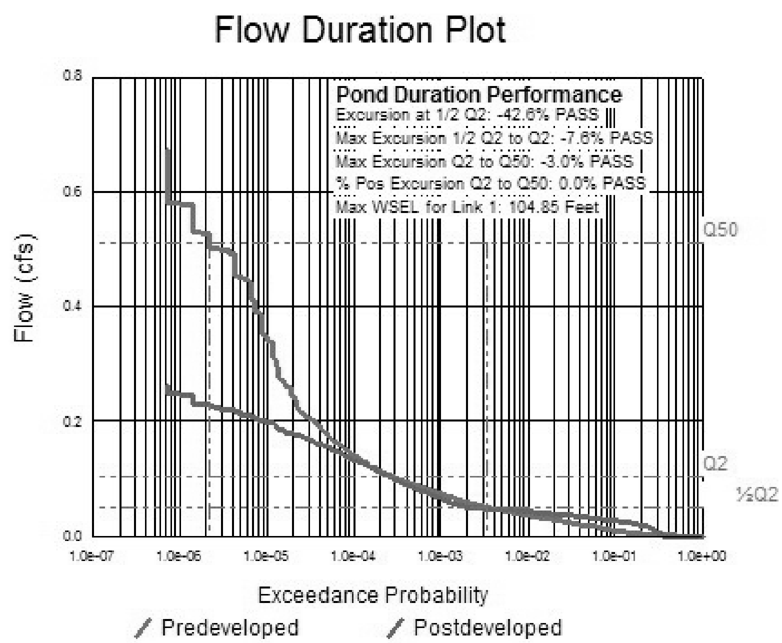
8. Click the *Use Elevation Volume Table*. Then click the Open Pond Elevation Volume Input Screen.
9. Copy the rating table from the spreadsheet to the Pond Elevation-Volume Table
10. Click OK to close the table, then OK to close the Structure input screen.



11. From the Runoff/Optimize Tab, Click Route. Make sure the Optimize box is <u>not</u> checked.
12. Check the performance. In this case, the performance was not met. We need a bigger vault. The diameter or length could be increased.



13. Return to the spreadsheet and increase the length to 1200 feet
14. Open the link definition and the elevation, area, volume table.
15. Copy the rating table and reroute the flows.
16. This iteration shows that the pipe vault 1200 feet long, 5' in diameter would work.


Flow Duration Plot
Pond Duration Performance
Excursion at 1/2 Q2: -42.6% PASS
Max Excursion 1/2 Q2 to Q2: -7.6% PASS
Max Excursion Q2 to Q50: -3.0% PASS
% Pos Excursion Q2 to Q50: 0.0% PASS
Max WSEL for Link 1: 104.85 Feet
Flow (cfs)
0.8
0.6
0.4
0.2
0.0
Q50
Q2
½Q2
1.0e-07
1.0e-06
1.0e-05
1.0e-04
1.0e-03
1.0e-02
1.0e-01
1.0e+00
Exceedance Probability
Predeveloped
Postdeveloped